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Planktological Study on the Warm Tsushima Current Regions - III

Plankton Properties and Their Relation to Oceanographic Conditions of Noto Peninsula～Nyudo Saki Region during the Seasons from Spring to Winter, 1952

by

Toshimasa SHIMOMURA

1 Introduction

In June, August and October, 1952, investigations of marine productivity at Mogami Bank in the Japan Sea were carried out under co-operation with Japan Sea Reg. Fish. Res. Lab. and Yamagata Pref. Fish. Exp. St.. The former shared in oceanographical investigations and ecological behaviors of migratory fishes, and the latter population studies of bottom fishes. The tracks of the "Dai-ni Asahi Maru", research vessel of Japan Sea Reg. Fish. Res. Lab., covered the region from Noto Peninsula to Mogami Bank and Nyudo Saki, Akita Pref. as shown in figure 1.

In these three cruises, physico-chemical surveys were made, plankton were collected at 23～32 stations in each cruise.

the first cruise : June 4～12, 1952, 32 samples.

the second cruise : August 2～10, 1952, 30 samples.

the third cruise : October 7～18, 1952,23 samples.

2 Acknowledgement

The author was aided by Mr. K. Miyata, Mr. S. Machinaka and other persons in collecting the material at the sea and in the chemical analysis of water samples on land. He was aided also by Capt. I. Tsuna and the crew of the "Dai-ni Asahi Maru" in the laborious and time consuming work on board. To all these gentlemen the author wishes to express his hearty thanks.

3 Method of collecting plankton

Plankton sample was collected by the vertical haul with Kitahara's plankton net. The net was lowered until the submerged length of the wire reached 25 meters and then hauled up roughly vertically to the sea surface. The filtering cone of the net was made of XX No. 13 silk bolting cloth (corresponding to Müller gauze No. 13), and provided at the bottom with a small bucket (glass tube) having a cock. The mouth of the net measured 22 cm. in diameter. The sampling time covered various hours, without regard to day or night.

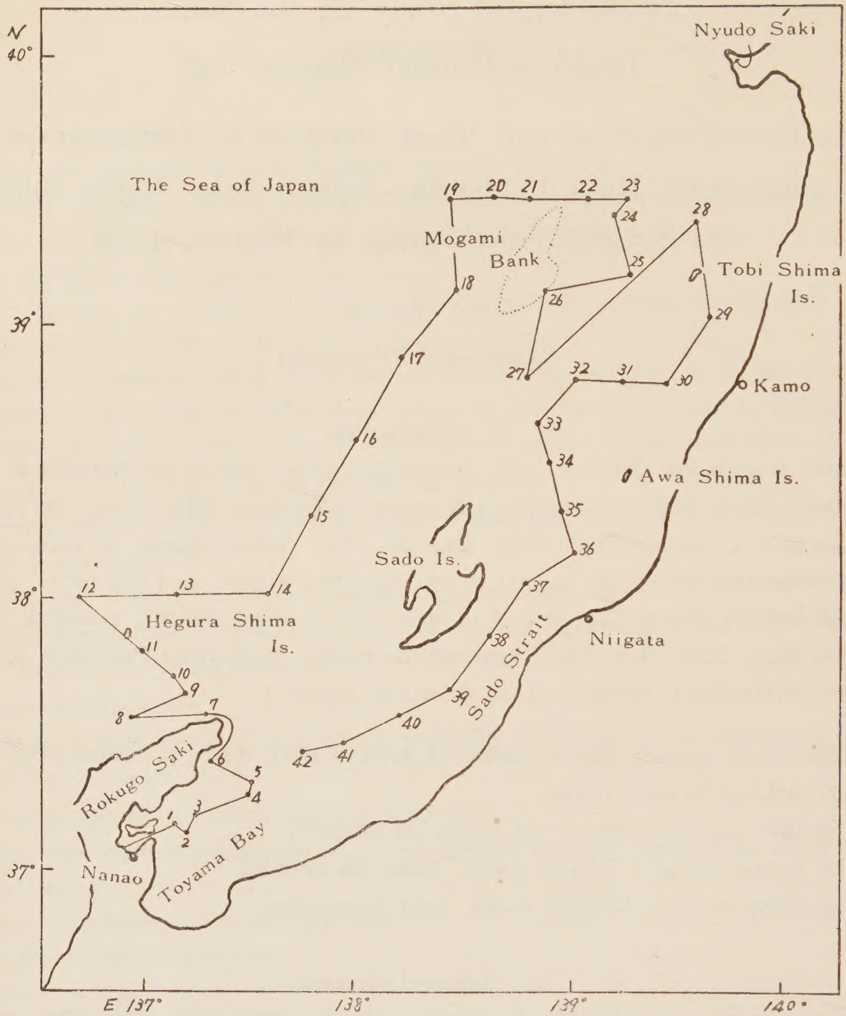


Fig. 1 The positions of standard stations throughout June, August and October, 1952.

4 Quantitative examination of plankton samples

The material was diluted with water about five times or more as much as its settling volume, and 1 cc. of the diluted sample was poured into a counting chamber, measuring 22 mm. by 27 mm. inside and 1.6 mm. deep, with a glass bottom sectioned at 0.5 mm. intervals. The chamber is made by fastening its brass side to the glass bottom with canada balsam. Counting was made under microscope, usually on the whole area of the chamber.

5 Number of species

Number of total species

Number of total species throughout zooplankton and phytoplankton were 87 in June,

104 in August, 144 in October. Complete list of the species appears in the Appended Table Ⅰ-Ⅱ added at the end of this thesis. Table 1 gives number of these species for different classificatory groups. The number of total species reached the largest value in October, especially it was strikingly large in plant species, more than twice that in June.

Table 1. Number of total species occured in each month.

Group \ Month	June	Aug.	Oct.
Total	87	104	145
Zooplankton	49	53	61
Protozoa	1	3	9
Copepoda	22	27	27
Other Crustaceae	6	5	4
Larvae	16	12	16
Miscs.	4	6	5
Phytoplankton	38	51	84
Cyanophyceae	1	1	1
Dinoflagellata	5	14	23
Diatomaceae	31	35	60
Chlorophyceae	1	1	0

Number of total animal species, as well as that of each classificatory group of animal, hardly shows seasonal increase and decrease. But only Protozoa group increase in number of species, though a small number, with advance of months. This phenomenon is due to the increase of that of Tintinnoinea group which not occurred in June and in August. In number of Copepoda species, Gymnoplea and Podoplea bear number half and half, on the whole, in June, but Gymnoplea take up a greater portion in August, and Podoplea predominate in October, vice versa.

Among phytoplankton species, Cyanophyceae has only one group, genus *Trichodesmium*, which occurs only in Toyama Bay in June, but at all stations throughout the neritic and offshore region in August and October. Dinoflagellata increase in number of species with progress of months, being caused by that of gen. *Peridinium* and *Ceratium* from June to August, gen. *Dinophysis* and others from August to October as follows.

Month \ Group	June	Aug.	Oct.
Peridinium	0	3	5
Ceratium	5	11	9
Miscs.	0	0	9

Number of Diatomaceae species is from 30 to 35 in June and in August, but it in October increases as much as about twice. This is owing to that of the three component groups of Diatomaceae —*Chaetoceros*, *Rhizosolenia*, and "others", of which "others" shows the most striking increase in number of species during the period

from August to October. In the period June-August, number of species of *Chaetoceros* and "others" do not vary except *Rhizosolenia*, as follows.

Month \ Group	June	Aug.	Oct.
Chaetoceros	14	15	19
Rhizosolenia	5	10	16
Others	12	10	25

Monthly change

The monthly change is as follows.

June : number of animal species > number of plant species
August : 〃 〃 〃 ≒ 〃 〃 〃
October : 〃 〃 〃 ≪ 〃 〃 〃

Figure 2 (a, b, c) shows the geographical distribution of number of total species in each month.

June : In the neritic region north of Sado Is., number of animal species and plant species are about equal, but in other regions the former is larger. Number of animal species varies between 3 (st. 35) and 20 (st. 5) according to stations, when plant species varies between 1~15 (st. 3). Animal is abundant (more than 10 species) in neritic region around Noto Peninsula, including Toyama Bay, while plant (generally below 7 species) does not show large geographical difference except locally abundant areas such as st. 29.

Number of total species is more abundant in neritic region (over 16°C.) than in offshore region (below 16°C.), namely 16°C. isotherm at the surface water forms a boundary.

August : As previously indicated, number of total species throughout the whole region under investigation increases strikingly, reaching 104 in August compared with 87 in June. This remarkable increase is caused by that of plant species. This is a large characteristic in August.

Number of animal species to occur at one station varies between 4 (st. 30) and 17 (st. 6), similarly in June. There found no geographical characteristics, also.

In June, number of animal species is larger than that of plant at all stations, but in August these two become equal or rather the latter more abundant.

October : As mentioned previously, number of total species throughout the whole region increases more and more, reaching 145 in October compared with 104 in August. This astonishing increase is due to that of plant species. Number of plant species to occur at one station varies between 26 (sts. 17 and 18) and 42 (st. 12), as much as twice for August and several times for June.

But animal species do not suffer remarkable change compared with that in August, and plant species become as much as twice to several times of animal species at each station. Number of total species is most abundant in the north region of Sado Is. (more than 50 speices). The minimum is encounted at Mogami Bank (about 45 species).



Fig. 2,a Number of species at each station, in June, 1952.

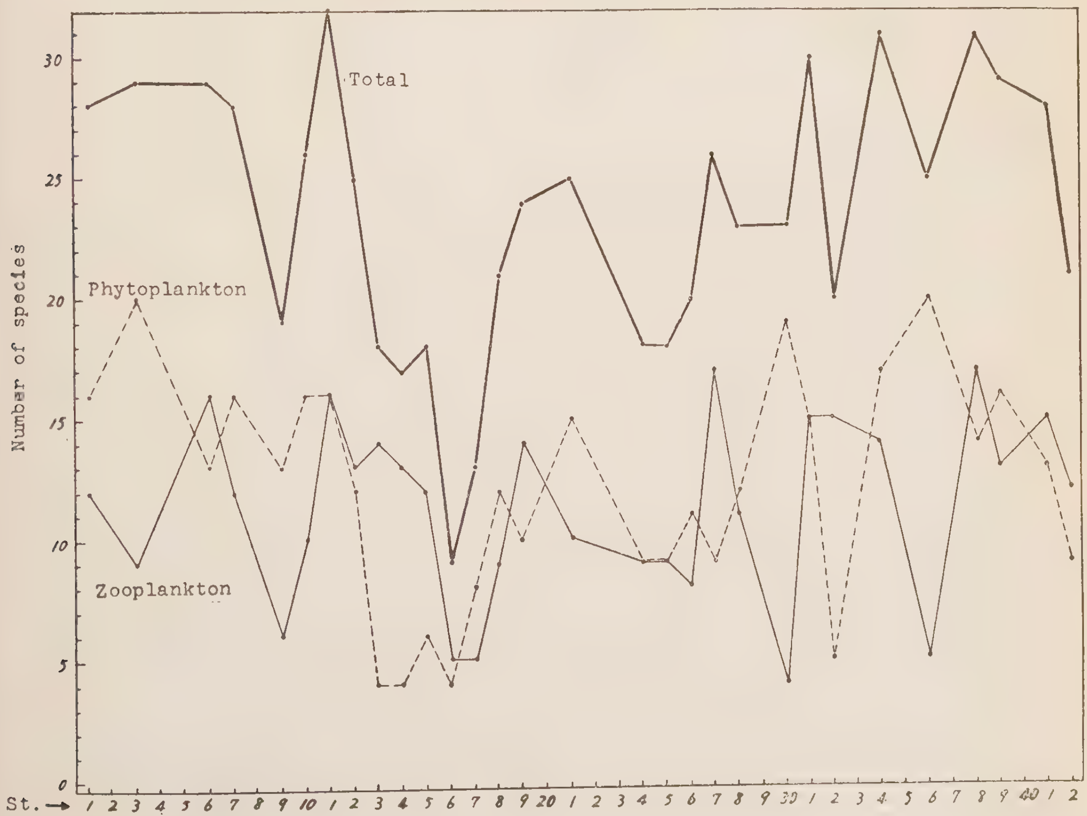


Fig. 2,b Number of species at each station, in August, 1952.

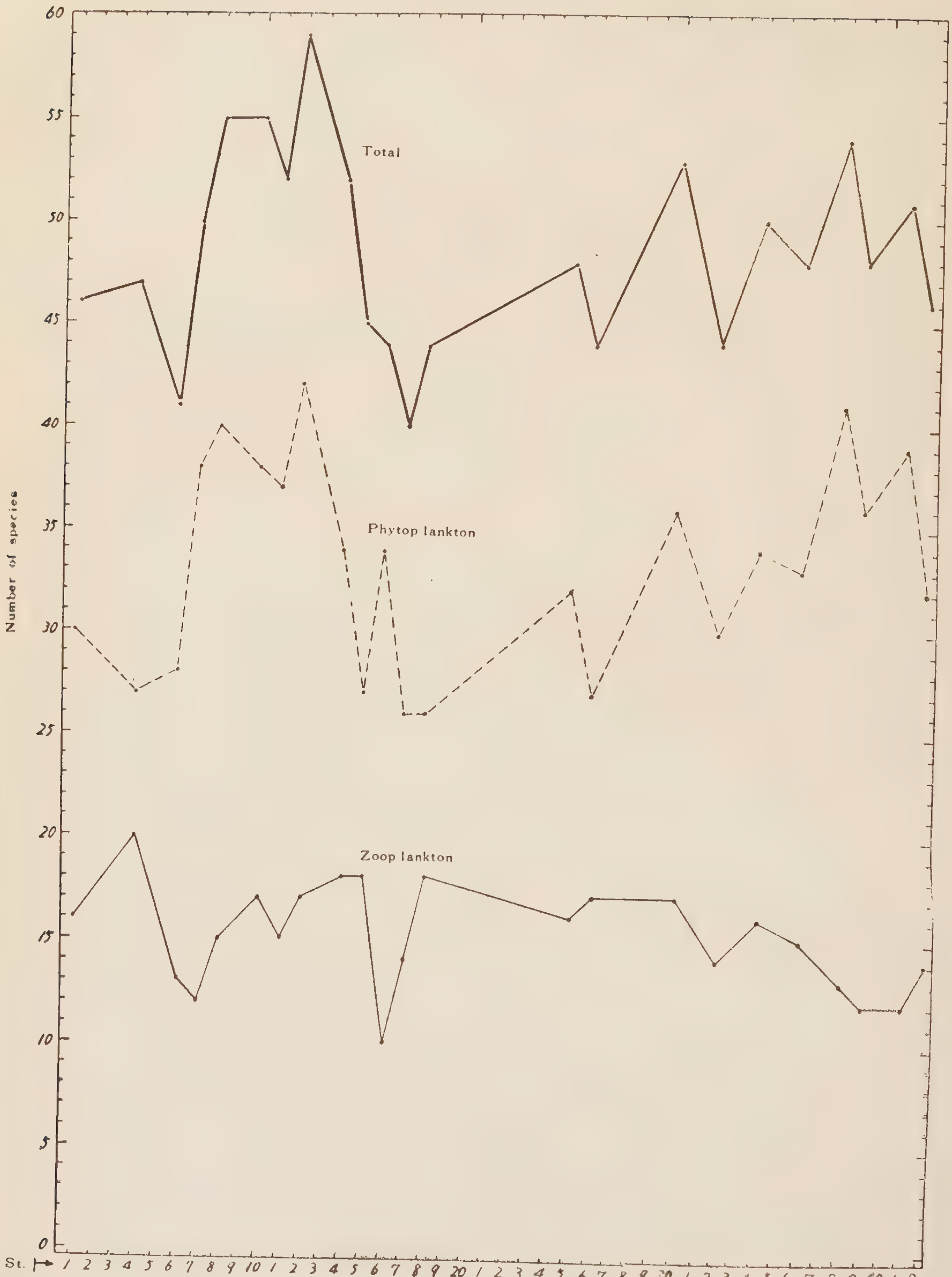


Fig. 2,c Number of species at each station, in October, 1952.

As mentioned above, number of total species shows remarkable increase from month to month, primarily owing to that of plant species. This change is shown as follows.

June : Number of animal species $>$ number of plant species
August : 〃 〃 〃 ≒ 〃 〃 〃
October : 〃 〃 〃 ≪ 〃 〃 〃

Number of animal species

Geographical and seasonal changes of Copepoda group and Larvae group which primarily determine number of animal species are given in figure 3.

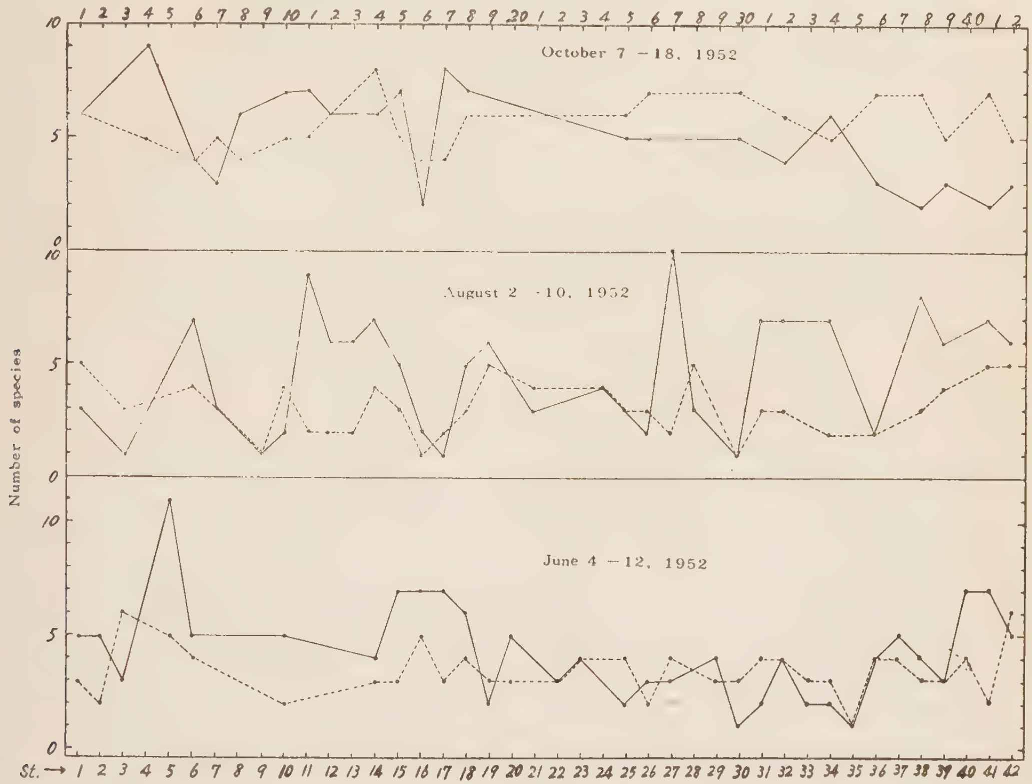


Fig. 3 Number of species of *Copepoda* and larval forms at each station.
•——• : Copepoda •·······• : Larval forms

In the waters around Noto Peninsula, including Toyama Bay, and in the offshre region, number of species is always Copepoda $>$ Larvae in each month. In other regions it is roughly Copepoda ≒ Larvae, though Copepoda $<$ Larvae only in October. This is, as shown in the Appended Table 3, due to the occurrence of larvae species such as Copepodite at all stations in October. In other words, this month is the flourishing time of number of larvae species throughout the northern Japan Sea.

Number of plant species (fig. 4)

Number of plant species is primarily determined by that of Diatomaceae, except Toyama Bay and the waters around Noto Peninsula where Dinoflagellata species flourish considerably. But such a geographical difference of Dinoflagellata species disappears in October.

Three component groups of Diatomaceae — *Chaetoceros*, *Rhizosolenia* and "others" —

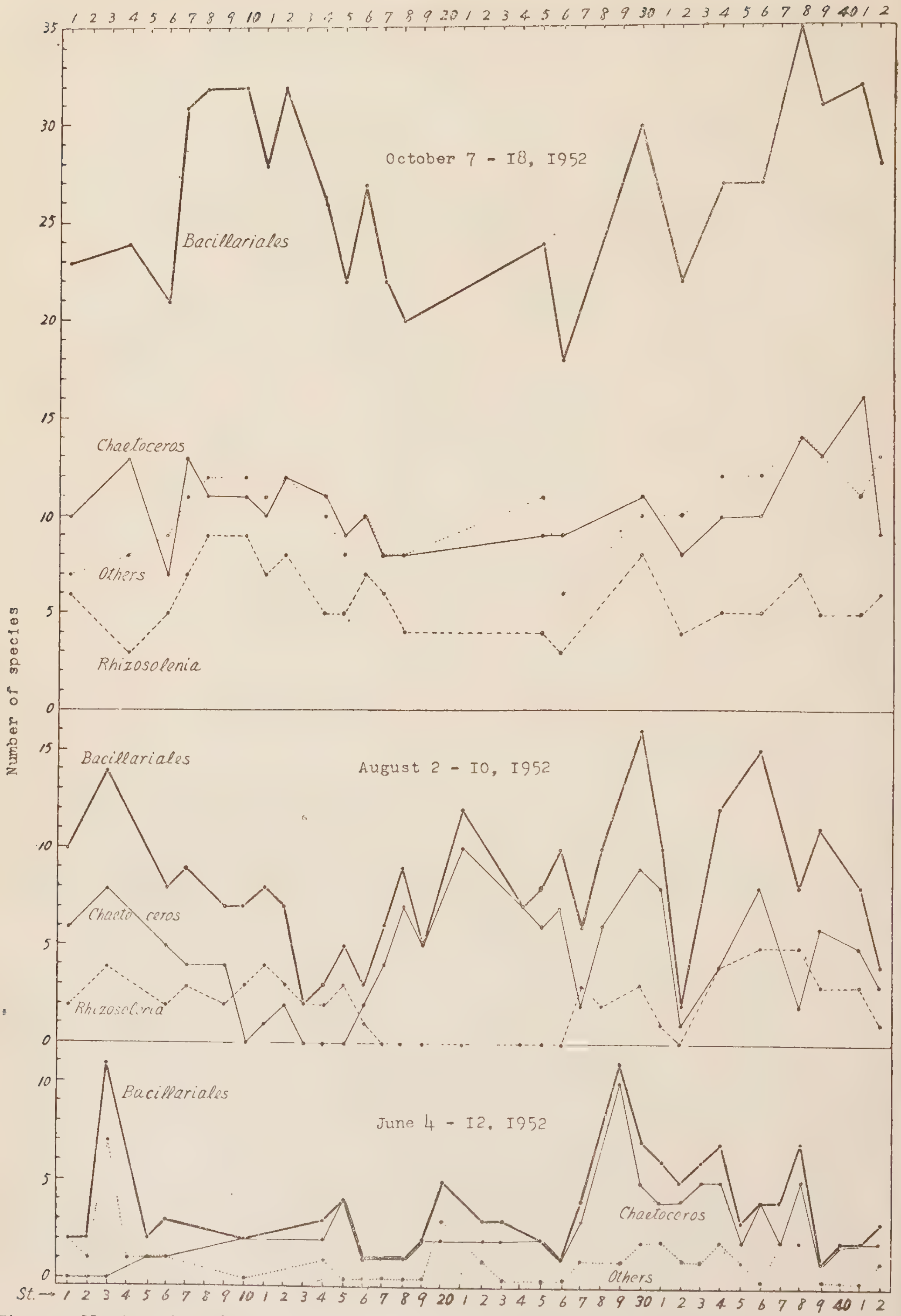


Fig. 4 Number of species of *Bacillariales*, gen. *Chaetoceros*, gen. *Rhizosolenia* and *Others* at each station.

show geographical and seasonal change as follows.

i) June : The geographical change in number of Diatomaceae is perfectly at the mercy of that of *Chaetoceros* species, except "others" in the waters around Noto Peninsula. The occurrence of *Rhizosolenia* species is 0 or 1 at each station.

ii) "Others" in the waters around Noto Peninsula disappears nearly, on the other hand *Rhizosolenia* considerably flourishes in the neritic region from Noto Peninsula to Honshu. Namely, although *Chaetoceros* is still the most chief component of Diatomaceae, its percentage to number of Diatomaceae species becomes lower than in June at each station.

iii) Above named three groups of Diatomaceae come together to occur at each station and balance itself on larger number of species. Namely, number of *Chaetoceros* species and "others" species vary between 7 and 13, respectively, *Rhizosolenia* between 3 and 8. In other words the ratio of number of *Chaetoceros* species to that of Diatomaceae species becomes smaller. But all these three groups coincide well with the curve of geographical change in number of Diatomaceae species.

6 Number of plankton organisms

Number of total organisms

Seasonal and geographical change in number of total organisms are shown in figure 5.

June : Total number varies between 6,783/m^3. (st. 26) and 264,782,854 (st. 32). It is noticed that the largest total number (generally more than 1,000,000/m^3.) appears always in the neritic region north of Niigata (sts. 27~35), and in other regions it is so small as poor as 20,000 per cubic meter of the sea water. This richest region is formed by the flourishing of plant organisms (100% in total number), but in the poorer region, animal organisms, especially Copepoda and Larvae, considerably flourish (generally, the ratio of animal organisms to total number is 60%).

On the other hand, the flourishing of plant organisms in the above named richest region is caused by that of *Chaetoceros* organisms which roughly account for 100% of plant organisms, and this phenomenon is due to the flourishing of one of specific species, *Chaetoceros affinis*.

October : It is noticed that the geographical change in number of total organisms is the smallest compared with that in June and in August, and also October is the flourishing period of plankton organisms for the northern Japan Sea. Total number varies between 126,680/m^3. (st. 6) and 2,727,004/m^3. (st. 7) (generally, between 300,000/m^3. and 1,000,000/m^3.). In other words, the richest region in June fade out to some extent, and the poorer region flourishes more and more (about 50 times that in June). After all, in October the northern Japan Sea is in flourishing time caused by the heavy growth of plant organisms which reach about 100% of total number at each station.

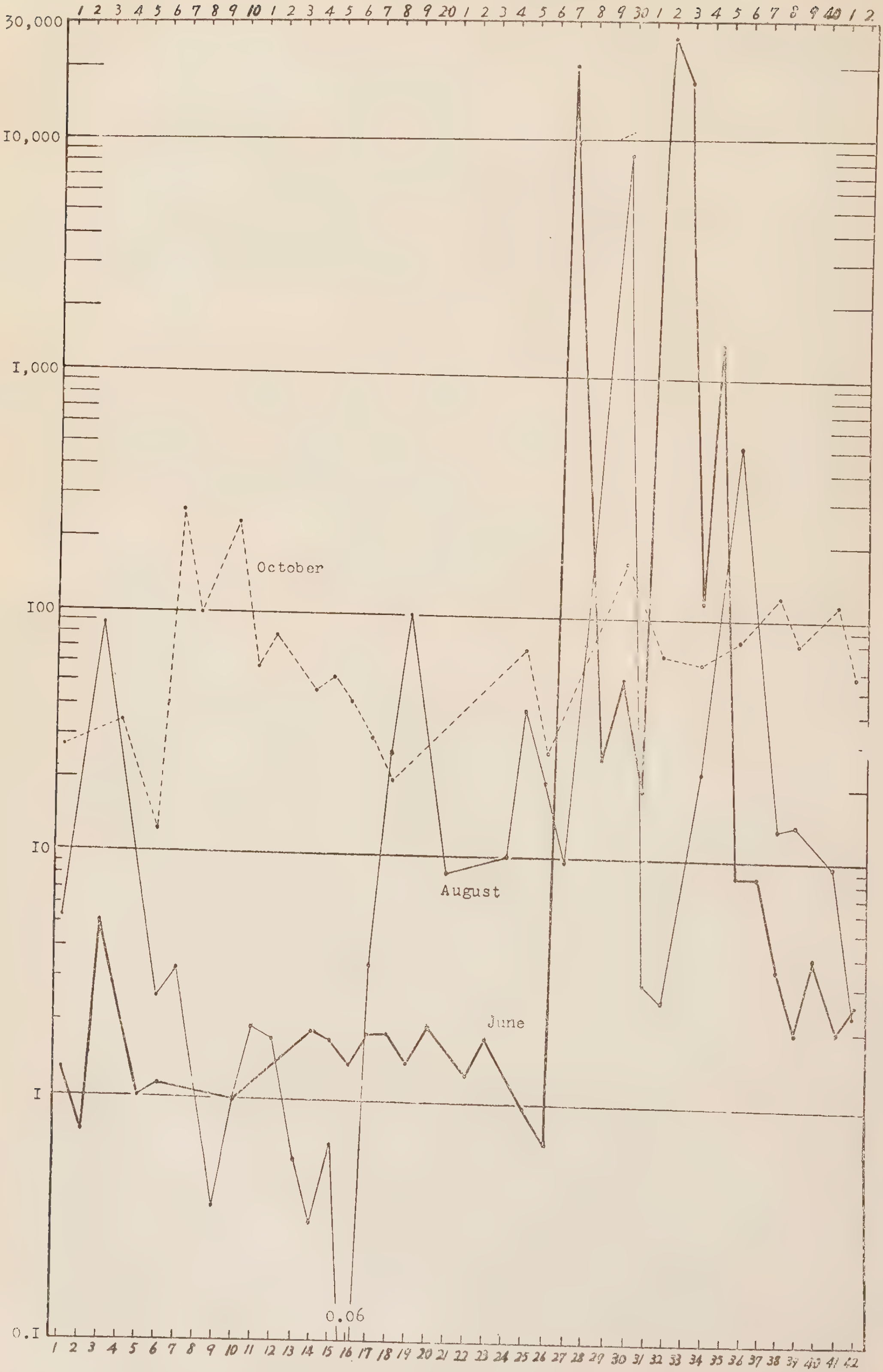

30,000
10,000
1,000
100
10
1
0.1
October
August
June
0.06
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

Fig. 5 Seasonal change of number of total organisms per cubic metre of sea water in the year 1952.

Abscissa —— Station number

Ordinate —— Number of total organisms per cubic metre of sea water (unit : 10,000).

This heavy growth is not caused by remarkable flourishing of specific dominant species as in June, but increasing in number of species and that of organisms in each species. This phenomenon is, also, a characteristic feature in October.

August : This month shows an intermediate character between June and October. Number of total organisms varies from 607/m³. (st. 16) to 84,942,676/m³. (st. 22). The larger number more than 1,000,000/m³. occurs only at four stations —sts. 3, 19, 30, and 36— which lie all in the neritic region. On the other hand, it is strikingly small at several stations, e. g. 607/m³. at st. 16. Namely, in August geographical change in plankton organisms is so remarkable.

These above mentioned phenomena represent that the richest region and neritic region in June show a tendency to decrease in number of organisms, and that, on the other hand, the poorer region in June is going to enter flourishing time such as sts. 3 and 9. August is the converting time to the flourishing period throughout the northern Japan Sea and is the period of the first step to higher level in total number.

This is also made out in the seasonal change of plant percentage in total number. In June, the plant percentage is generally less than 40% in the region except the neritic region north of Niigata, but in August it increases up to 65~100% in this region, in consequence of the flourishing of Diatomaceae organisms. In October it reaches about 100% at each station. Namely, standing on plant-ratio point, plant organisms in the neritic region north of Niigata is always 100% throughout June, August and October, while in other regions it shows considerable seasonal change as follows : —

June : less than 40%

August : less than 90%

October : 100%

On the other hand, in August, the preponderance due to some species shows also an intermediate character, between June and October ; number of predominant species is larger than in June (only one species), but smaller than in October (sevearal species). As later mentioned, the dominant species in August is five species such as *Chaetoceros affinis*, *Climacodium biconcavum*, *Rhizosolenia styliformis*, *Ch. didymus*, and gen. *Ceratium*.

Number of animal organisms

The geographical and seasonal change of animal ratio in the total number are against these of plant ; in the neritic region north of Niigata, animal ratio shows always uniform level, 0~several % throughout June, Augut and October ; in other regions, these changes are as follows : —

June : more than 60%

August : 0-40%

October : 0-several %

The seasonal changes of animal organisms are as follows : -

June : 1,904/m^3. (st. 37) ~ 23,800/m^3. (st. 30)

generally, 5,000/m^3. ~ 20,000/m^3.

August : 214/m^3. (St. 16) ~ 40,520/m^3. (st. 19)

generally, 400/m^3. ~ 40,000/m^3.

October : 833/m^3. (st. 25) ~ 14,637/m^3.

generally, 5,000/m^3. ~ 10,000/m^3.

Namely, as in number of total organisms, the seasonal change is large in the named order :

August > June > October

And in June the richest region (more than 10,000/m^3.) lies in the offshore region of Sado Is. (sts. 14—23), and in August this region moves to the neritic region north of Niigata. In October, when the geographical change is the smallest, there found no special flourishing region, and Toyama Bay is the poorest region (gnerally, 5,000/m^3. or thereabout).

The richer region in June is formed by the flourishing (50-60%) of Larvae group of which *Oithona* is dominant, and in August by the flourishing (50%) of Copepoda group as well as *Noctiluca*-*Sticolonche* group (Protozoa). The declining in Toyama Bay in October is caused by the general decaydance throughout all group, including Copepoda group.

Number of plant organisms

The seasonal chan ges of plant organisms are as follows : -

June : 155/m^3. (St. 16) ~ 264,775,000/m^3. (St. 32)

August : 393/m^3. (St. 16) ~ 84,926,016/m^3. (St. 30)

October : 122,931/m^3. (St. 6) ~ 2,718,198/m. (St. 7)

As are shown above, this geographical change is so large that can not compare with that of animal organisms. As plant organisms constitutes the major part of total organisms, the seasonal and geographical change of plant organisms entirely amounts to that of total number.

June : Plant flourish over 1,000,000/m^3. in the neritic region north of Niigata, and in other regions, is below 100,000/m^3. (generally, less than 10,000/m^3.) ; it shows a sudden change. This flourishing is caused by *Ch. affinis*, which constitutes the major part of plant organisms, in that region.

August : As in total organisms, August is the converting time from June to October in number of plant organisms as well as species. Namely, the neritic region north of Niigata decreases to some extent in number of plant organisms, though it is the richest region from June on ; number of dominant species increases to two species, *Ch. affinis* and *Ch. curvisetus*, compared with only one, *Ch. affinis*, in June.

October : The superiority of some specific plants reaches the lowest level. A considerable dominant species is *Ch. didymus*, reaching 25-50% in number of total plant organisms. In the richest region (more than 1,000,000/m^3.), or in the waters around Noto Peninsula, *Ch. brevis* which holds 20% or so contributes to the flourishing of plant organisms, in addition to *Ch. didymus*.

7 Dominant species

The northern Japan Sea during the period from June to October is a world of "Chaeto-plankton". In respect of the very animal, it is the sea of Copepoda and the sea of Larvae ; in June, Copepoda and larvae, respectively, account for 50% or thereabout of number of animal organisms at each station. In August, the percentage of larvae declines and that of Copepoda increases. In the waters around Noto Peninsula from st. 1 to st. 11, there occur no dominant s pecies but mixing flora of Protozoa, Copepoda, Larvae and Miscs.. It is a characteristic in October that larvae group dominates (50-90%) throughout the whole region under investigation and Copepoda drops below 20% of animal organisms.

The absolute majority of plant organisms is hold by *Chaetoceros* at each station, through June, August and October, but *Rhizosolenia* and other Diatomaceae are dominant groups, flourishing in the waters around Noto Peninsula in June, and in the offing (sts. 11-20) in August. It is a noticeable characteristic in October that following three groups, at each station, show distinct difference in the quantitative ratio to animal organisms in the following order.

Chaetoceros >	*Other Diatomaceae* >	*Rhizosolenia*
(50～75%)	(20～40%)	(below 10%)

Animal organisms

June (fig. 6) : Except the surrounding waters of Noto, June is a dominant time of *Oithona similis* and *Oithona* copepodite ; *Oithona* group holds 50-90% of animal organisms at each station. *Paracalanus parvus* occur well at each station but less than 25%. The waters around Noto have no remarkable dominant species. In this region *Microsetella norvegica* and *Oikopleura spp.* are considerably dominant with the above named two species. In this case, the geographical change of *Oithona similis* is not always similar to *Oithona* copepodite.

August (fig. 7) : In this month, the predominance of *Oithona* group as mentioned above, go down to under 50%, yet this species with *Paracalanus parvus* shows the most remarkable superiority.

In the neritic region, including the waters around Noto, the two species-*Sticholonche zanclea* and *Noctiluca scintillans* increase up to 50% in number of animal organisms. In addition to this, Gymnoplea copepodite which occur throughout the whole region also flourish to considerable extent.

October : As mentioned previously, October is a period increasing in number of

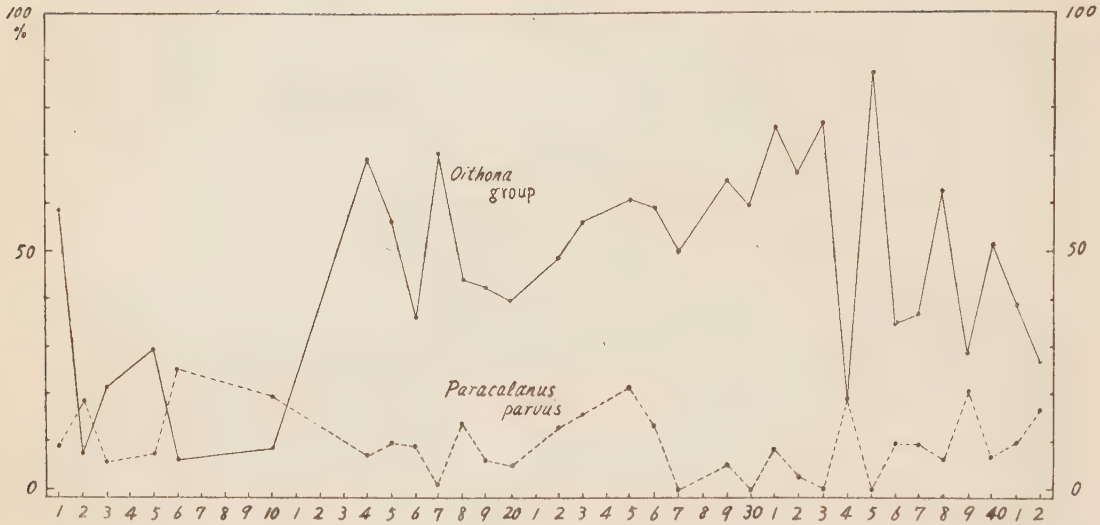


Fig. 6 Numerical percentage of *Oithona* group and *Paracalanus parvus* to zooplankton orgasnims at each station, in June, 1952.



Fig. 7 Numerical percentage of chief components of zooplankton to zooplankton organisms, in August, 1952.

species, and has no remarkable dominant species. In the case of number of animal organisms, the tendency also bears a striking resemblance to this. Nauplius larvae, *Oncaea* larvae and Gymnoplea copepodite are, if anything, the dominant species, but these reach, respectively, no more than 30% of animal organisms. Of these Gymnoplea copepodite falls in percentage down compared with August, and Nauplius larvae and *Oncaea* larvae flourish more than twice as much as that in August.

Phytoplankton

June (fig. 8) : *Ceratium* (*tripos*, *carriense*, *macroceros*), *Ch. peruvianus* and *Ch.*

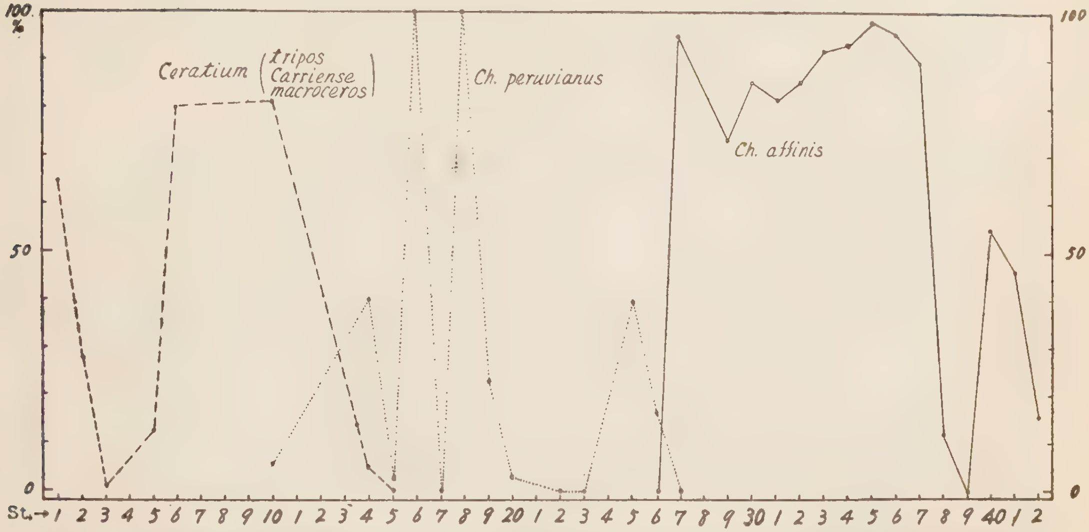


Fig. 8 Numerical percentage of dominant species to phytoplankton organisms at each station in June 1952.

affinis show respectively striking predominance more than 80% of phytoplankton organisms in several regions. In addition to this, these three species show a sharp habitat segregation, respectively, as follows : -

Ceratium (tripos, carriense and macroceros)
... in the waters around Noto Peninsula

Ch. peruvianus ... in the offshore region

Ch. affinis .. in the neritic region

August (fig. 9) : August is, as previously stated, a time converting from June to October, and the

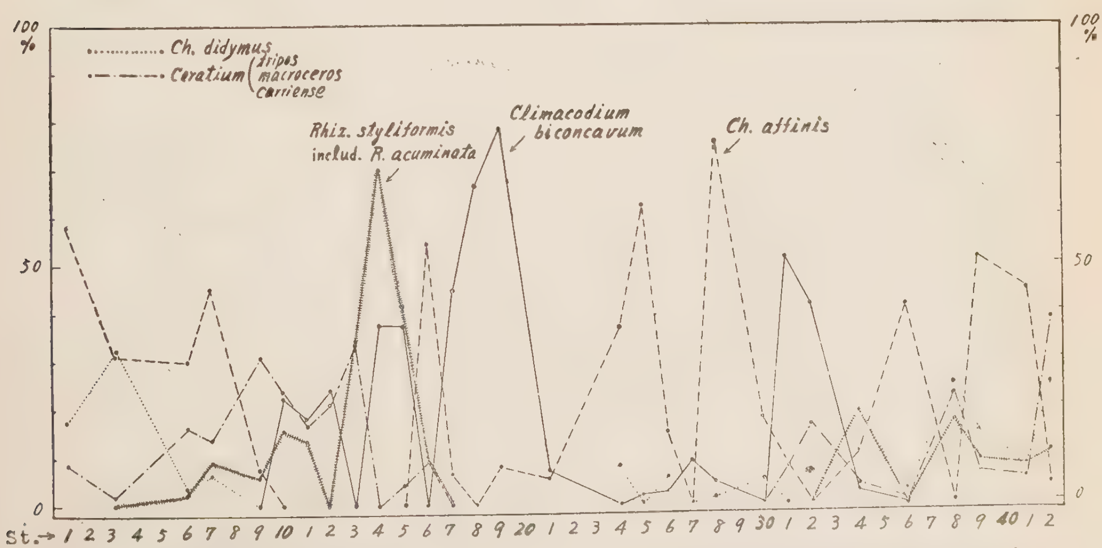


Fig. 9 Numerical percentage of chief components of phytoplankton to phytoplankton organism,s in August, 1952.

superiority of some species is not so remarkable as in June ; the three dominant species in June all fall down in percentage to phytopankton organisms, and especially the fall of *Ch. peruvianus* is extreme (less than 2% of plant organisms), scattering in occurrence at stations.

August is the month for the following three species. But in

Chaetoceros affinis

Rhizosolenia styliformis (*var. latissima, longispina, acuminata*)

Climacodium biconcavum

the waters around Noto and in Toyama Bay, *Ch. didymus* and genus *Ceratium* flourish respectively to the maximum 30% of plant organisms, and also *Ch. affinis* flourishes considerably.

October : This month is the flourishing time of number of pant species like in the case of animal, and all species occur at each station. All these species do not grow more than several per cent of plant organisms—*Ch. didymus* is the only dominant species in October, reaching 20-50% of plant organisms, and *Thal'x Frauenfeldii* (less than 15%) comes after it. Namely, the increasing in number of plant organisms

Table 2. Dominant species in each month.

	Month	Dominant species	Main occurrence region
Zooplankton	June	*Oithona* group {*O. similis*, *O.* copepodite}	throughout the whole region
	Aug.	*Oithona* group	off region
		Paracalanus parvus	〃 〃
		Sticholonche-Noctiluca group	neritic region
	Oct.	Nauplius larva	throughout the whole region
		Gymnoplea copepodite	〃 〃
		Oncaea copepodite	〃 〃
Phytoplankton	June	*Ceratium* group {*C. tripos*, *C. macroceros*, *C. carriense*}	neritic region around Noto Penisula
		Chaetoceros peruvianus	off region
		Chaetoceros affinis	neritic region of Japan Proper
	Aug.	*Rhiz. styliformis* group	off region
		Climacodium biconcavum	〃 〃
		Chaetoceros affinis	throughout the whole region
		In the region around Noto Peninsula and in Toyama Bay, the following species are relatively dominant with about 30% of phytoplankton organisms	
		Chatoceros didymus	
		Ceratium group	
	Oct.	*Chaetoceros didymus*	throughout the whole region

results from that of plant species.

The above mentioned are summarized as table 2.

8 Each dominant species

1) **Oithona group** : This group is the only dominant species in June, and is nearly composed of *Oithona similis* and *Oithona* copepodite. This group occurs in the most abundance in June, reaching the maximum of percentage to number of animal organisms and the maximum of number of organisms. The maximum value of percentage and that of number of organisms of this group vary with months as follows :-

June : 88% (st. 35), 15,000/m³.
August : 52% (st. 18), 8,000/m³.
October : 4.4%, 500/m³.

Both the percentage and number of organisms in August go on decreasing than in June. But the flourishing region lies yet in the offshore region north of latitude 38° N. through out neritic region and offing. In October, in contrast with August, it remains only in neritic region such as Toyama Bay and the Sado Strait but little in the offing north of lat. 38°N.. The above mentioned is summarized as table 3.

Table 3. Geographical, seasonal change of percentage and number of organisms in *Oithona* group.

Percentage & number	Month	In the waters around Noto Peninsula	North of lat. 38 N	In Toyama Bay
Numerical percentage of *Oithona* group to the number of zooplankton organisms	June	below 30%	generally 40~80%	30~50%
	Aug.	generally below 15%	〃 20~50%	below 10%
	Oct.	below 3% (Occurrence is rare)	always 0%	〃 4%
Number of *Oithona*-group organisms	June	generally below 500/m.³	generally 4,000~10,000/m.³	generally 1,000~5,000/m.³
	Aug.	〃 〃 300/m.³	1,000~8,000/m.³	〃 below 1,000/m.³
	Oct.	〃 〃 200/m.³	does not appear at all	〃 〃 250/m.³

As *Oithona similis* and *Oithona* copepodite represent the same geographical distribution, these are, en bloc, to be dealed as one group—*Oithona* group. Namely, *Oithona* group flourishes, both in number of organisms and in its percentage to animal organisms, in the lowest temperature region (16°C. level in June and 23°C. in August). This group, on the other hand, euryhalinous, flourishing through from the lowest salty region (16.5 Cl ‰) to the highest (18.9 Cl ‰). SiO_2 content and O_2 saturation are irrelevant to the flourishing, as far as this investigation concerned. In October, notwithstanding the stabilization of surface water temperature at 22°C., the distribution is limited only in neritic region.

2) **Paracalanus parvus**

This species is a remarkable dominant one in June, ranking next to *Oithona* copepodite, and appears in the most abundance in August. In October, it disppears at all stations, decreasing to 100/m³. or so in number. This species shows a great variation

in geographical distribution as follows : -

June :	less than 30% (generally 10%)	less than 2,500/m³.
August :	less than 45% (generally 25%)	less than 8,500/m³.
October :	less than 2%	about 100/m³.

Paracalanus parvus occurs well in abundance, both in June and in August, in the lowest temperature region of each month and also in the neritic region such as the innermost part of Toyama Bay, and the percentage to animal organisms is as good as the above mentioned. This species is also euryhalinous one.

3) **Sticholnnche-Noctiluca group**

Sticholonche zanclea does not occur throughout the region under investigation in June, *Noctiluca scintillans* occurs only in the waters around Noto (2-3%).

While in August, these two species appear throughout the whole region, and the densest population is found in the neritic region (generally 20-40%), including the waters around Noto Peninsula. The maximum value in percentage reaches 50% (3,000 /m³.), and that in number of organisms 5,940/m³. at st. 34.

Also in October, this group occurs at each station but no more than several per cent. Namely this group is a warmth-loving and neritic being, flourishing in the highest temperature region (over 24°C.) in August. For this investigation, it is euryhalinous one and it occurs well in abundance even in low salty region of 17 Cl ‰.

4) **Nauplius larva**

This group occurs in the greatest abundance in October. During the period from June to August, it is generally less than 10% of zooplankton organisms, and rises to 15-30% in October (22°C. level, 18.1～18.4 Cl ‰). Number of organisms also increase to 3,000/m³. or thereabout. Every month it tends to flourish in neritic region than in the offing.

5) **Gymnoplea copepodite**

This group appears in the range between 15°C.and 25°C., and at each station spring through autumn. It shows remarkable variation from station to station, flourishing in the most abundance in the Mogami Bank region and in the neritic region. In October, its percentage to animal organisms is hold on an smoothed value (generally 10～30%) at each station. It is euryhalinous, flourishing in the saltiest region (16 Cl ‰)as well as in the lowest (17 Cl ‰).

6) **Oncaea copepodite**

This group is a chief component in number of animal organisms in October with Nauplius larva and *Gymnoplea* copepodite, bursting entirely upon the view. Namely it occurs scarcely at each station in June, and only several per cent in the waters around Noto and in Toyama Bay, in August. But in October, it occurs at the greater part of the region under investigation, reaching 10～30%.

In respect of number of organisms, this group is neritic one (less than 2,000/m³. in the offshore region but more than 3,000/m³. in the neritic), Water temperature

and chlorinity of the northern Japan Sea in October is 22°C. level and 18.2 Cl ‰ level, respectively.

7) **Ceratium group**

This group contains the following three species which act

Ceratium tripos

Ceratium macroceros

Ceratium carriense

similary on the occurring period and the region and the like. The occurrence is limited in the waters around Noto (17°C.) in June, reaching the highest value 80% (9,000 /m^3.). As the waters around Noto in June is a decreasing region of number of plant organisms, number of *Ceratium* organisms is of deep significance.

This group appears, in August, not only in the waters around Noto but in Toyama Bay.⁎ The percentage of this group is, on the whole, no more than 30% and number of organisms is less than 30,000/m^3..

In October, this group occurs at each station, though it decreases under 1%. The water temperature in the northern Japan Sea ranges from 22° to 23°C. in October, and shows rather an approximate value to that in August ; nevertheless number of organisms does not increase as much as in August.

In short, this group is a warmth-loving and euryhalinous form, showing the richest abundance of about 30,000/m^3. even in the lowest salty region (17.5 Cl‰).

8) **Chaetoceros peruvianus**

This species flourishes in the most abundance in the early summer and also in the offshore region. But, during August and October, it is little worth consideration, accounting for only 1 to 2%. Although this species holds 100% in the fewest region where number of plant organisms is merely 200/m^3. or so such as sts. 16 and 18, it is not so important from the quantitative point of view.

The largest number of organisms in June is 1,800/m^3. at St. 14. The richest region is placed within the lowest temperature region (15°C. or so) in June. On the other hand, chlorinity is stable between 18.3‰ and 18.8‰ in the period from June to October. Namely its flourishing and declining in number of organisms might exceedingly be affected by water temperature.

9) **Chaetoceros affinis**

This species is the most important one in *Chaetoceros* group which controls the geographical distribution of number of total organisms, including zooplankton and phytoplankton. The most noticeable features in this species are as follows.

i) This species flourishes only in summer (June and August).

ii) In June, it occurs only in the neritic region (sts. 27~42), and flourishes more than 80% of number of plant organisms.

⁎ The surface water temperature in the waters around Noto and in Toyama Bay are all above 25°C. in August, being the highest value through June, August and October.

iii) In August, it occurs at each station, enlarging the distributing region, but the percentage to the plant organisms falls below 75%.

iv) In October, it is less than 4% for all stations

The seasonal change of the highest value is as follows :-

June .... 96% ... 230,000,000/m³.

August .... 75% ..., 16,000,000/m³.

October .... 5.2% ... 60,000/m³.

The highest value of number of organisms and of the percentage to the plant organisms lie, together, in the highest temperature regions in June and in August (18°-19°C. and 25°C., respectively). While, in October, the two values are not directly connected with water temperature, becoming stable between 22°~23°C.. The species is euryhalinous, flourishing well both in the salstiest regions with 18.9 Cl ‰ (June-August) and in the lowest with 16.5 Cl ‰.

10) **Rhizosolenia styliformis**

In this species, *Rhiz. styliformis var. latissima* and *Rhiz. acuminata* are included for convenience sake. Namely, gen. *Rhizosolenia* appears generally in small abundance and only in August ; moreover, the largest number is merely 40,000/m³. or so. In the waters around Noto where plant organisms occur in small number, the percentage to plant organisms reaches 70% at some stations, in August.

Rhiz. styliformis does not appear at all in June, when *Rhiz. alata* occurs only in few numbers in the innermost part of Toyama Bay. In August, *Rhiz. styliformis* takes place of *Rhiz. alata*, dwindling again below 1% in October. The distribution also becomes limited in the neritic region both in August and October.

Rhiz. styliformis is a warmth-loving species (above 20°C.) and a euryhalinous form.

11) **Climacodium biconcavum**

This species occurs only in summer, appearing suddenly when the water temperature rises over 23°C. in August. It is an indicator form of the main flow of the Tsushima Current and occurs generally more than 20% of phytoplankton organisms, reaching 80% at some stations. Number of organisms increases more than 1,000/m³., and the largest number is 800,000/m³. at St. 19. This species is also a warmth-loving and euryhalinous form, flourishing in the lowest temperature region (23°C. level) in August, and in the saltiest region over 18.7 Cl ‰.

On the contrary, it disappears in the offshore region —the main flow of the Tsushima Current— in October, occurring only in the neritic region. But it is generally below 2% of plant organisms, the water temperature and chlorinity of the occurring region decrease to 22°C. and 18.2‰, respectively.

12) **Chaetoceros didymus**

This species occurs during the period from summer to autumn, no appearing in spring. The flourishing seems to be restrained under 18.0 Cl ‰.

This species occurs at each station in October, reaching 20-50% of plant organisms.

Namely this form is one of the dominant species in October. Number of total organisms varies generally between 100,000-800,000/m³.. The chief flourishing region lies in the neritic region, not in the main flow of the Tsushima Current. Such a tendency is most remarkable in August, and the distribution in August is mainly limited in the waters around Noto and in Toyama Bay. Though the percentage in plant organisms is below 30%, number of organisms for each station is subject to remarkable fluctuations (0 5,000,000/m³.).

The highest flourishing region of this species lies in the highest temperature region (25°~26°C.) in August.

9 Summary

1) The material for this study was collected during the period June 4-12, August 2-10 and October 7-18, 1952, at 32 stations, 30 stations and 23 stations, respectively, scattering in the northern Japan Sea from Noto Peninsula to Nyûdô Saki. At each station a vertical haul was made through the uppermost 25-metre layer. The numerical abundance and quantitative and qualitative composition of plankton are studied upon these 85 samples. And the seasonal and geographical distribution of these planktological properties are discussed in relation to physico-chemical conditions of the sea.

2) The plankton samples were collected with the Kitahara's plankton net. The filtering cone of the net consists of XX No. 13 silk bolting cloth (corresponding to Müller gauze No. 13). The mouth of the net measured 22 cm. in diameter.

3) Number of total species increases with advance of months, in June 87 species, in August 104, and in October 145. Such an increase is mainly due to that in number of plant species.

The seasonal change in number of animal and plant species through the whole region is as follows : -

June : number of animal species > number of plant species
August : 〃 〃 〃 ≒ 〃 〃 〃
October : 〃 〃 〃 ≪ 〃 〃 〃

4) On number of organisms

The northern Japan Sea is the sea of "Chaeto-plankton" during the period from June to October. Number of total organisms varies between 0 and 264,782,854/m³. (St. 32, June).

The remarkable features in the seasonal change are as follows;—

i) In June, *Chaetoceros affinis* is the only dominant species, holding the majority in number of total organisms. From the geographical view of point, the neritic region north of Niigata is the most abundant region with usually over 1,000,000 per cubic meter of the sea water, the other region is less than 20,000/m³..

ii) In October there found no noticeable dominant species. The increase in number of total organisms is caused by that in number of species and in number of

organisms of each is the smallest in October compared with June and August.

iii) August shows just the intermediate feature between June and October in number of dominant species and the geographical variation in number of total organisms.

5) From the geographical point of view, several dominant species in each month are studied, arranging in tables.

6) The most chief components or 12 species through the entire period covered by this study are picked out, and the seasonal and geographical change and the relations to the sea conditions are studied.

7) As the observation stations lie entirely in the neritic region in the Tsushima Current and the sea conditions are also a monotonous warm season type, the plankton samples for this study consist exclusively of pure warmth-loving forms. It should be remembered in this connection that the whole area covered by this study is free the direct influence of the cold oceanic current from the north during the observation period, and that the net is hauled only through the upper-most layer of the sea (0-25m. zone). Therefore, it is not able to correlate the distribution of plankton to the flow of the Tsushima Current.

10 Literature

1. Gran, H. H. (1905). Diatomeen. *Nordisches Plankton.* xix, *Botanischer Teil.* In German.
2. Hustedt, F. (1930). Die Kieselalgen Deutschlands, Östereich und der Schweiz mit Berücksichtigung der übrigen Länder Europas sowie der angrenzende Meeresgebiete. I-II Teil. (Rabenhorst's Ktyptogamen-Flora von Deutschland, Östereich und der Schweiz. Bd. VII). In German.
3. Kawarada, Y. (1953). Plankton association in Japan Sea and Tsugaru Straits in May, 1950. *Jour. Oceanog. Soc. Jap.* **9** (2). In Japanese.
4. Lebour, M. V. (1930). The plankton Diatoms on northern seas. In English.
5. Mori, T. (1937). The pelagic Copepoda from the neighbouring waters of Japan. Tokyo. Yokendo. In English.
6. Shimomura, T. (1954). Planktological study on the warm Tsushima Current regions-I & II. *Ann. Rep. Japan Sea Reg. Fish. Res. Lab.* **1**. In English.

Appended Table 1　List of plankton species captured with Kitahara's net during the period June 4–12, 1952.

St. No.	2	10	6	9	14	15	16	17	18	26	25	23	22	20	19	29	30	31	32	27	33	34	35	36	37	38	39	40	41	42	[illegible]	[illegible]
Latitude (N)	37°37′	37°42′30	37°23′30	37°11′	38°00′	38°18′	38°34′	38°49′30	39°07′30	39°08′	39°10′	39°27′	39°26′.0	39°26′	39°26′	39°01′30	38°46′	38°46′30	38°47′	38°47′	38°37′	38°[illegible]	38°16′	38°08′30	38°01′30	37°49′30	37°38′	37°3[illegible]′	37°[illegible]5′30	37°[illegible]4′	37°1[illegible]′	37°11′
Longitude (E)	137°13′	137°09′	137°20′	137°10′	137°34′	137°47′	138°00′	138°14′	138°27′	138°52′	139°15′	139°14′30	139°0.8′	138°37′	138°24′30	139°37′	139°25′	139°13′	139°00′	138°46′30	138°49′	138°53′	138°55′30	139°00′	138°46′30	138°37′	138°26′	138°1[illegible]′	137°57′	137°4[illegible]′	137°[illegible]	137°1[illegible]′
Date	5th	6th	4th	4th	5th	5th	6th	6th	6th	6th	6th	6th	6th	6th	6th	6th	9th	9th	9th	9th	9th	9th	10th	10th	11th	11th	12th	11th	11th	11th	12th	12th
Time	0940	1130	1430	1220	1555	1920	2250	0200	0520	0850	1200	1520	1700	2100	2250	1240	1345	1525	1725	1920	2115	2225	0125	0310	1040	1385	1550	1805	2025	2380	0180	0505
Total number of plankton inds./m³.	7,259	9,877	11,246	12,995	18,802	17,505	14,066	18,743	18,564	6,783	9,437	18,207	12,852	20,278	14,280	260,372	5,609,660	196,112	264,782,854	199,690,568	168,748,426	1,163,106	13,493,886	87,108	86,989	35,986	19,754	41,055	20,349	25,704	9,754	62,894
Zooplankton																																
Number of zooplankton inds./m³.	5,117	5,474	8,568	8,663	14,042	12,055	13,911	18,207	18,326	6,069	8,663	13,387	11,186	11,424	11,186	9,520	23,800	4,141	7,854	8,568	6,426	5,712	2,856	6,426	1,904	7,664	7,854	17,255	4,879	10,234	7,854	2,202
Percentage to the total plankton	70.5	55.4	76.2	66.7	74.7	68.9	98.9	97.1	98.7	89.5	91.8	73.5	87.0	56.3	78.3	3.7	0.4	2.1	*tr.*	*tr.*	*tr.*	0.5	*tr.*	7.4	2.2	21.3	39.8	42.0	24.0	39.8	80.5	3.[illegible]
Phytoplankton																																
Number of phytoplankton inds./m³.	2,142	4,403	2,678	4,332	4,760	5,450	155	536	238	714	774	4,820	1,666	8,854	3,094	250,852	5,585,860	196,350	264,775,000	199,682,000	168,742,000	1,157,394	13,491,030	80,682	85,085	28,322	11,900	23,800	15,470	[illegible]	[illegible]	[illegible]
Percentage to the total plankton	29.5	44.6	23.8	33.3	25.3	31.1	1.1	2.9	1.3	10.5	8.2	26.5	13.0	33.7	21.7	96.3	99.6	97.9	100.0	100.0	100.0	99.5	100.0	92.6	97.8	78.7	60.2	58.0	76.0	[illegible]	19.[illegible]	[illegible]
Inclination of the wire of net	50°	70°	20°	50°	50°	20°	10°	40°	50°	48°	30°	50°	40°	10	20°	30°	40°	35°	30°	56°	20°	15°	10°	10°	20°	40°	52°	54°	23°	60°	50°	10
Percentage to the zooplankton																																
Protozoa	2.3	2.2	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	16.[illegible]
Copepoda	60.4	54.4	54.2	42.8	25.5	45.3	43.7	45.1	30.9	41.1	48.2	45.3	48.9	55.0	31.9	45.0	20.0	13.8	57.6	52.7	59.3	31.2	62.5	37.0	25.0	38.0	50.0	43.4	56.0	41.8	53.9	13.[illegible]
Larval forms	7.0	10.8	12.5	39.3	57.6	50.6	43.7	48.0	50.7	47.1	42.9	38.7	36.2	37.5	63.8	52.5	80.0	80.9	33.3	30.5	33.3	43.8	25.0	53.7	65.6	55.4	39.4	45.6	44.0	53.5	29.6	67.5
Percentage to the phytoplankton																																
Cyanophyceae	11.1	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*tr.*	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	17.6
Dinoflagellata	27.8	81.1	80.0	64.3	5.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	53.1	2.0
Diatomaceae	61.1	13.5	20.0	35.7	95.0	100.0	100.0	100.0	100.0	16.7	100.0	100.0	100.0	45.1	69.2	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.9	76.5	10.0	65.0	76.9	69.3	15.7	74.4
Chlorophyceae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.2	30.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	23.5	85.0	35.0	23.1	26.9	31.2	5.9
Percentage to the zooplankton																																
Noctiluca scintillans Macartney	2.3	2.2	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	16.2
Calanus helgolandicus (Claus)	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.1	0.0	0.0	0.0	0.0	2.3	0.0
〃 *tenuicornis* Dana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.4	0.0	1.5	0.0
Paracalanus parvus (Claus)	18.6	19.6	25.0	8.9	6.8	9.3	9.2	1.0	14.2	13.7	21.4	16.0	12.[illegible]	5.0	6.4	5.0	0.0	8.6	3.0	0.0	0.0	18.7	0.0	9.3	9.4	6.5	21.2	6.9	9.8	16.3	7.6	5.4
〃 *aculeatus* Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4
Clausocalanus arcuicornis (Dana)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *furcatus* (Brady)	0.0	0.0	0.0	0.0	0.0	6.7	18.4	0.0	2.6	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	3.0	2.8	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	7.0	14.4	0.0
〃 *pergens* Farran	0.0	0.0	0.0	0.0	0.0	1.3	1.1	7.8	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
〃 *sp.*	0.0	0.0	0.0	1.8	0.0	4.0	0.0	0.0	0.0	3.9	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	1.4	7.3	0.0	2.3	0.0
Pseudocalanus minutus (Kröyer)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0
Oncaea venusta Philippi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.7	0.0	0.0	3.0	0.0
〃 *media* Giesbrecht	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.7	2.4	0.0	2.3	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corycaeus japonicus sp. nov.	0.0	2.2	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.1	0.0	0.0	2.4	2.3	0.8	0.0
Metridia lucens Boeck	0.0	0.0	0.0	0.0	0.0	1.3	1.2	2.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
Oithona setigera Dana	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *nana* Giesbrecht	0.0	8.7	4.2	10.7	5.1	4.0	2.3	2.0	0.0	0.0	0.0	4.0	4.2	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *similis* Claus	4.7	0.0	2.1	19.6	11.9	18.7	10.3	25.5	5.2	23.5	26.8	24.0	31.9	32.5	25.5	22.5	20.0	5.2	45.5	44.4	55.6	12.5	62.5	18.5	6.3	29.3	27.3	29.6	14.6	13.9	17.4	2.7
〃 *rigida* Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *plumifera* Baird	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	32.5	21.7	20.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Microsetella norvegica (Boeck)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
〃 *sp.*	2.3	0.0	0.0	1.8	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Evadne tergestina Claus	4.7	0.0	6.2	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *spinifera* P. E. Müller	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Podon Leuckarti G. O. Sars	0.0	0.0	2.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euphausiacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(1)*	0.0	0.0	0.0
Parathemisto oblivia (Kroeyer)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
Amphipoda	0.0	0.0	0.0	0.0	3.4	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medusae	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0
Sagitta spp.	4.7	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Oikopleura spp.	20.9	32.6	14.6	5.4	13.5	4.0	11.5	6.9	18.2	11.8	8.9	16.0	14.9	7.5	4.3	2.5	0.0	5.2	9.1	16.7	7.4	18.7	0.0	9.3	9.4	6.5	10.6	11.0	0.0	3.5	10.6	2.7
Muggiae	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nauplius larva	2.3	0.0	0.0	8.9	3.4	10.7	11.5	1.0	5.2	11.8	1.8	2.7	0.0	0.0	0.0	7.5	0.0	10.3	0.0	16.7	7.4	6.3	0.0	14.8	9.4	4.4	6.1	2.8	0.0	8.1	2.3	8.1
Paracalanus juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clausocalanus juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.7	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oncaea juv.	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0
Corycaeus juv.	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
Oithona juv.	0.0	0.0	0.0	28.6	52.5	33.3	23.0	43.1	39.0	35.3	33.9	28.0	12.8	7.5	17.0	30.0	40.0	62.0	21.2	5.5	22.2	6.3	25.0	16.7	31.2	33.7	1.5	22.1	24.4	12.8	12.1	18.9
Calanoida juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	6.9	6.1	5.5	0.0	31.2	0.0	16.7	15.6	17.4	31.8	13.8	19.5	25.6	8.3	21.6
Copepodite	0.0	6.5	2.1	0.0	0.0	6.6	5.7	3.9	3.9	0.0	5.4	5.3	8.5	7.5	19.1	0.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shizopoda juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mysis larva	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pelecypoda larva	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda larva	4.7	0.0	2.1	0.0	1.7	0.0	2.3	0.0	2.6	0.0	1.8	2.7	0.0	0.0	0.0	0.0	0.0	1.7	3.0	2.8	3.7	0.0	0.0	5.5	9.4	0.0	0.0	6.9	0.0	1.2	6.1	10.8
Ophiopluteus larva	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7
Maurolicus Pennanti Walb (Egg)	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pisces egg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4
Larval Pisces	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Percentage to the phytoplankton																																
Trichodesmium sp.	11.1	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*tr.*	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	17.6
Ceratium tripos O. F. Müller	0.0	10.8	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *extensum* (Gourr.) Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *macroceros* (Ehrbg.) Cleve	0.0	0.0	6.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	12.5	1.0
〃 *leptosomum* Jörgensen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40.6	1.0
〃 *carriense* Gourret	27.8	70.3	73.3	57.1	5.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaetoceros concavicornis Mangin	0.0	0.0	0.0	0.0	0.0	10.5	0.0	100.0	0.0	0.0	0.0	0.0	42.8	29.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *peruvianus* Brightwell	0.0	5.4	6.7	0.0	40.0	2.6	100.0	0.0	100.0	16.7	40.0	0.0	0.0	3.2	23.1	0.9	0.0	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.0	8.8	0.0	0.0	0.0	0.0	6.3	0.0
〃 *pelagicus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0
〃 *convolutus* Castracane	0.0	0.0	0.0	0.0	0.0	42.1	0.0	0.0	0.0	0.0	0.0	77.8	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.1	0.0	1.3	0.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0
〃 *danicus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	2.2	0.0	0.0	0.0	3.6	*tr.*	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *didymus* Ehrenberg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *affinis* Lauder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.6	85.4	81.5	85.7	95.5	92.0	93.0	98.2	96.5	89.5	11.8	0.0	55.0	46.1	15.4	0.0	0.0
〃 *compressus* Lauder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.1	0.0	1.6	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *diversus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *curvisetus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *tetrastichon* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0	46.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *spp.*	0.0	8.1	0.0	0.0	50.0	44.7	0.0	0.0	0.0	0.0	0.0	18.5	28.6	0.0	0.0	10.5	1.4	6.5	7.7	1.8	1.3	1.8	0.0	1.8	3.5	14.7	10.0	10.0	30.8	7.7	0.0	0.0
Rhizosolenia setigera Brightwell	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9
〃 *alata* Brightwell	38.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *alata f. genuina* GRAN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
〃 *Stolterfothii* H. Perag.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9
〃 *imbricata* Brightwell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
Nitzschia seriata Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.6	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	4.9
〃 *longissima* (BrèB.) Gran	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8
Bacteriastrum hyalinum Lauder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	6.1	7.3	4.8	2.6	1.6	1.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *spp.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	5.9	0.0	0.0	0.0	0.0	9.4	0.0
Thalassionema nitzschioides Grunow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*tr.*	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thalassiothrix Frauenfeldii Grunow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Leptocylindrus danicus Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.6
Pleurosigma spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.2	0.0	4.9
Navicula sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.7
Coscinodiscus radiatus Ehrenberg	0.0	0.0	6.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *spp.*	22.2	0.0	0.0	32.1	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragillaria sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7
Licmophora abbreviata AGARDH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.2	30.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	23.5	85.0	35.0	23.1	26.9	31.2	5.9

Appended Table 2 List of plankton species captured with Kitahara's net during the period Aug. 2–10, 1952.

St. No.	1	6	7	9	10	11	12	13	14	15	16	17	18	19	21	24	28	25	26	30	31	32	27	34	36	38	39	41	42	3
Latitude (N)	37°11′	37°25′	37°33′	37°38′	37°42′	37°47′	38°00′	38°00′	38°00′	38°18′	38°35′	38°52′	39°10′	39°28′	39°26′	39°23.5′	39°22.5′	39°10′	39°10′	38°46′	38°46′	38°46′	38°46′	38°27.5′	38°08′	37°50′	37°40′	37°26.5′	37°21′	37°11′
Longitude (E)	137°11′	137°22′	137°18′	137°12′	137°07′	137°00′	136°44′	137°10′	137°38′	137°49′	138°02′	138°12′	138°24′	138° 24.5′	138°47′	139°10′	139°33′	139°10′	138°47′	139°26′	139°13′	139°00′	138°47′	138°53′	139°00′	138°37′	138°26′	138°00′	137°45′	137° 16.5′
Date	Aug. 2	Aug. 2	Aug. 3	Aug. 3	Aug. 3	Aug. 3	Aug. 3	Aug. 3	Aug. 4	Aug. 4	Aug. 4	Aug. 4	Aug. 4	Aug. 4	Aug. 4	Aug. 5	Aug. 5	Aug. 5	Aug. 5	Aug. 7	Aug. 7	Aug. 7	Aug. 7	Aug. 8	Aug. 8	Aug. 9	Aug. 9	Aug. 10	Aug. 10	Aug. 10
Time	1200	1510	0805	0915	1030	1205	1600	2030	0010	0400	0900	1210	1600	1940	2300	0155	0700	0950	1300	1500	1705	1920	2130	0140	0610	1800	2100	0200	0720	0950
Total number of plankton inds./m³.	55,355	26,656	34,272	3,570	10,413	19,397	17,493	5,617	3,106	6,546	607	35,612	267,750	1,017,058	86,632	101,007	773,405	409,217	204,014	84,942,676	31,238	25,942	96,628	229,688	5,212,130	134,708	138,040	95,438	24,157	919,870
Zooplankton																														
Number of zooplankton inds./m³.	6,609	3,570	3,570	428	2,440	6,069	10,591	1,333	821	655	214	459	5,117	40,520	8,330	3,689	3,808	4,284	7,143	16,660	10.175	23,086	21,182	15,946	33,845	15,708	4,284	4,998	2,232	5,474
Percentage to the total plankton	1.0	13.4	10.4	12.0	23.4	31.3	60.5	23.7	6.4	10.0	35.3	1.3	1.9	4.0	9.6	3.7	0.5	1.0	0.5	tr.	32.6	89.0	21.9	6.9	0.6	11.7	3.1	5.2	9.7	0.6
Phytoplankton																														
Number of phytoplakton inds./m³.	49,266	23,086	30,702	3,142	7,973	13,328	6,902	4,284	2,285	5,891	393	35,153	262,633	976,538	78,302	97,318	769,597	404,933	196,874	84,926,016	21,063	2,856	75,446	213,742	5,178,285	119,000	133,756	90,440	21,825	914,396
Percentage to the total plankton	99.0	86.6	89.6	88.0	76.6	68.7	39.5	76.3	73.6	90.0	64.7	98.7	98.1	96.0	90.4	96.3	99.5	99.0	96.5	100.0	67.4	11.0	78.1	93.1	99.4	88.3	96.9	94.8	90.3	99.4
Inclination of the wire of net	40°	50°	20°	15°	55°	60°	40°	40°	40°	44°	45°	40°	22°	50°	25°	30°	45°	45°	30°	50°	52°	45°	50°	40°	40	42°	10°	9°	30°	30
Percentage to the zooplankton																														
Protozoa	50.9	20.0	30.0	33.3	39.0	35.9	36.1	3.6	4.3	9.1	0.0	18.2	2.3	1.3	8.5	3.2	0.0	5.6	6.7	14.3	15.8	3.1	9.0	31.3	28.6	22.7	16.7	4.7	28.6	26.0
Copepoda	11.8	29.9	23.3	11.1	4.8	15.4	37.0	60.6	65.0	54.5	50.0	9.1	65.1	51.1	71.4	80.7	18.7	22.2	20.0	28.6	45.7	52.4	58.3	52.2	42.9	45.6	44.5	52.4	39.2	17.4
Cladocera	0.0	16.7	6.7	0.0	4.9	12.8	2.2	7.2	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	16.7	0.0	0.0	7.0	1.0	3.4	3.0	0.0	1.5	0.0	0.0	0.0	0.0
Miscs.	5.9	13.4	23.3	44.4	34.1	30.8	14.6	25.0	0.0	9.1	16.7	45.4	0.0	1.3	1.4	0.0	25.0	11.1	13.3	42.8	8.7	5.2	1.1	7.5	0.0	22.7	11.1	7.1	0.0	34.7
Larval forms	31.4	20.0	16.7	11.1	17.0	5.2	10.1	3.6	26.0	27.3	33.3	27.3	32.6	46.3	18.6	16.1	50.0	44.4	60.0	14.3	22.8	38.1	23.6	6.0	28.5	7.5	27.8	35.8	32.2	21.7
Percentage to the phytoplankton																														
Cyanophyceae	1.2	0.5	0.8	7.7	4.5	12.5	24.1	33.3	0.0	0.0	0.0	0.6	0.2	2.1	tr.	0.5	tr.	0.0	0.0	0.2	2.5	33.3	5.0	0.0	0.0	5.6	0.8	1.3	7.2	0.5
Dinoflagellata	8.5	15.9	14.8	33.8	35.0	19.7	20.7	33.3	1.6	4.0	9.1	0.2	0.5	2.0	3.0	tr.	tr.	tr.	tr.	tr.	9.4	16.6	2.2	5.0	0.4	24.6	5.9	4.8	38.6	3.7
Diatomaceae	90.2	83.5	84.4	49.2	60.5	67.8	55.0	33.3	98.4	96.0	90.9	99.1	99.3	95.8	97.1	96.6	100.0	100.0	100.0	98.7	88.0	50.0	92.7	95.0	99.5	69.8	93.3	93.9	54.2	95.8
Chlorophyceae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Percentage to the zooplankton																														
Noctiluca scintillans Macartney	7.8	6.7	6.7	11.1	24.4	30.8	36.0	3.0	4.3	9.1	0.0	0.0	0.0	1.3	7.1	3.2	0.0	5.6	6.7	0.0	15.8	3.1	9.0	28.3	0.0	13.6	0.0	4.7	28.6	4.3
Sticholonche zanclea Hustedt	43.1	13.3	23.3	22.2	14.6	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	3.0	28.6	9.1	16.7	0.0	0.0	21.7
Tintinnus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2	2.3	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calanus helgolandicus (Claus)	0.0	0.0	0.0	0.0	0.0	(3)	(12)	(4)	0.0	(3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Paracalanus parvus (Claus)	2.0	6.7	6.7	0.0	0.0	5.1	5.6	14.2	30.4	27.2	0.0	0.0	20.9	11.9	45.7	32.3	6.2	0.0	13.3	0.0	5.3	36.1	9.0	14.9	0.0	10.6	11.1	21.4	0.0	0.0
〃 *aculeatus* Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0
Acrocalanus sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clausocalanus pergens Farran	0.0	0.0	3.3	0.0	0.0	0.0	0.0	35.7	0.0	0.0	0.0	0.0	2.3	13.2	14.3	32.3	0.0	0.0	0.0	0.0	0.0	8.2	1.1	1.5	0.0	6.1	0.0	0.0	0.0	0.0
〃 *furcatus* (Brady)	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	4.3	0.0	0.0	0.0	7.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	3.5	4.1	7.9	11.9	0.0	6.1	11.1	0.0	3.5	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	8.7	0.0	0.0	0.0	0.0	9.7	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euchaeta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scolecithricella minor (Brady)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centropages sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
Temora stylifera (Dana)	5.9	3.3	13.3	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.5	0.0	0.0	0.0	0.0
〃 *discaudata* Giesbrecht	0.0	0.0	0.0	0.0	(8)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	3.6	0.0
Candacia bipinnata Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(2)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	(1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Labidocera japonica Mori	0.0	0.0	0.0	0.0	0.0	(1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oithona nana Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	22.5	3.9	4.3	18.2	0.0	9.1	7.0	3.1	0.0	0.0	0.0	0.0	0.0	28.6	8.8	1.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *similis* Claus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.9	6.6	11.4	12.9	0.0	11.1	0.0	0.0	15.8	1.0	21.3	9.0	0.0	4.6	0.0	4.7	7.1	0.0
Microsetella rosea (Dana)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
〃 *sp.*	0.0	3.3	0.0	11.1	0.0	5.1	0.0	0.0	4.3	0.0	33.3	0.0	0.0	0.0	0.0	0.0	6.3	5.6	6.7	0.0	1.8	1.0	2.2	1.5	14.3	4.6	0.0	0.0	3.5	0.0
Euterpe acutifrons (Dana)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	2.4	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	2.6	0.0	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oncaea media Giesbrecht	3.9	3.3	0.0	0.0	2.4	0.0	5.6	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	1.0	7.9	10.4	28.6	9.1	0.0	0.0	0.0	0.0
〃 *venusta* Philippi	0.0	3.3	0.0	0.0	2.4	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	3.5	0.0	4.5	0.0	0.0	3.0	11.1	16.7	17.9	17.4
Corycaeus gibbulus Giesbrecht	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0
〃 *agilis* Dana	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	(1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Evadne tergestina Claus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	16.7	0.0	0.0	5.3	1.0	3.4	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Podon Leuckarti G. O. Sars	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Penilia shmackeri Richard	0.0	16.7	6.7	0.0	4.9	7.7	2.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5	0.0	0.0	0.0	0.0
Temisto sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphipoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	(1)	0.0	(3)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Creseis acicula Rang.	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7
Cypridina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Doliolum nationalis Borgert	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	1.1	0.0	0.0	0.0	0.0	2.4	0.0	0.0
Fritillaria haplostoma Fol.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.8	0.0	0.0	0.0
Oikopleura spp.	3.9	6.7	13.3	33.3	34.1	30.8	9.0	21.4	0.0	0.0	0.0	45.4	0.0	0.9	0.0	0.0	6.3	11.1	10.0	42.8	7.0	2.1	3.4	7.5	0.0	18.2	8.3	4.7	0.0	13.0
Sagitta spp.	2.0	6.7	6.7	11.1	0.0	0.0	2.2	3.6	0.0	(5)	16.6	0.0	0.0	0.4	1.4	0.0	18.7	0.0	3.3	0.0	1.7	1.0	1.1	0.0	0.0	3.0	0.0	0.0	0.0	13.0
Nauplius larva	2.0	6.7	0.0	11.1	7.3	0.0	1.1	(4)	4.3	9.1	16.7	9.1	7.0	0.9	1.4	0.0	6.3	5.5	6.7	14.3	3.5	1.0	0.0	1.5	14.3	3.0	5.6	2.4	10.7	4.3
Paracalanus juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calanus juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	9.1	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnoplea juv.	3.9	0.0	0.0	0.0	0.0	2.6	0.0	3.6	8.7	9.1	0.0	18.2	9.3	33.5	10.0	6.5	6.2	0.0	13.3	0.0	3.5	34.0	9.0	0.0	14.3	3.0	11.1	16.7	10.7	8.7
Oithona juv.	17.6	6.7	6.7	0.0	4.9	0.0	0.0	0.0	8.7	0.0	0.0	0.0	16.3	7.5	4.3	3.2	25.0	33.3	40.0	0.0	15.8	3.1	14.6	0.0	0.0	0.0	2.8	11.9	0.0	8.7
Oncaea juv.	5.9	0.0	3.3	0.0	2.4	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corycaeus juv.	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda larva	0.0	3.3	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	3.6	0.0
Pelecypoda larva	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	1.5	8.3	2.4	3.6	0.0
Mysis larva	2.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ophiopluteus larva	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polychaeta larva	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0
Percentage to the phytoplankton																														
Trichodesmium sp. (Faden)	1.2	0.5	0.8	7.7	4.5	12.5	24.1	33.3	0.0	0.0	0.0	0.6	0.2	2.1	tr.	0.5	tr.	0.0	0.0	0.2	2.5	33.3	5.0	0.0	0.0	5.6	0.8	1.3	7.2	0.5
Peridinium falutipes Kofoid	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *depressum* Bailey	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceratium lunula Schimper	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *trichoceros* (Ehrbg.) Kofoid	3.9	6.7	4.3	15.4	10.4	5.4	6.9	33.3	0.0	4.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	1.7	8.3	0.0	1.1	0.0	11.2	2.5	2.5	3.4	0.5
〃 *Candelabrum* (Ehrbg.) Stein	0.0	0.0	1.1	1.5	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
〃 *Carriense* Gourret	2.4	3.6	3.9	9.2	4.5	6.2	3.5	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.3	3.8	0.9	0.4	3.1	0.5
〃 *macroceros* (Ehrbg.) Cleve	1.5	3.6	4.7	6.2	6.7	1.8	8.6	0.0	0.0	0.0	0.0	0.0	0.1	tr.	tr.	3.0	0.0	0.0	tr.	0.0	5.1	0.0	1.6	2.1	0.1	3.8	1.7	0.9	21.4	0.7
〃 *tripos* O. F. Müller	0.5	2.0	0.4	0.0	2.2	3.6	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	tr.	tr.	0.0	0.0	0.9	8.3	0.0	0.5	tr.	3.8	0.8	1.0	10.7	0.5
〃 *extensum* (Gourr.) Cleve	0.0	0.0	0.4	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sumatranum* (Karsten) Jörg.	0.0	0.0	0.0	0.0	7.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *nipponicum* Okamura	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.0	2.9	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.6	1.0	tr.	0.2	0.0	0.0	0.0	1.5
〃 *strictum* (Okam. et Nishikawa) Kofoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *inflatum* Kofoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0
Chaet. peruvianus Brightwell	0.0	0.5	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.1	0.1	tr.	2.9	1.1	0.0	0.0	1.1	0.0	0.9	8.3	2.8	0.0	0.1	0.0	1.7	0.0	0.0	0.0
〃 *coarctatus* Lauder	3.9	35.6	6.2	18.5	0.0	18.8	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.2	21.2	0.0	71.3	0.5	0.4	20.6	12.4	8.7	14.5	2.0
〃 *pelagicus* Cleve	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	20.0	20.2	4.1	5.0	12.5	19.2	tr.	0.0	0.0	0.0	11.3	0.0	0.0	0.0	0.0	4.9
〃 *affinis* Lauder	58.2	29.9	45.7	7.7	0.0	0.0	0.0	0.0	0.0	0.0	54.5	6.6	0.0	8.2	5.7	37.1	75.3	62.4	14.8	17.9	7.6	0.0	0.0	10.5	41.4	0.0	51.0	44.5	3.8	31.5
〃 *compressus* Lauder	0.0	0.0	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0	tr.	7.9	3.5	0.0	4.5	0.7	0.8	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	3.7
〃 *didymus* Ehrenberg	17.6	3.6	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	7.1	7.9	0.9	0.0	5.7	5.1	tr.	0.0	0.0	0.0	2.3	24.4	13.3	7.4	25.2	32.0
〃 *brevis* Schütt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	2.8	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.1
〃 *diversus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.0	0.0
〃 *Lorenzianus* Grunow	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.
〃 *curvisetus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	2.9	0.0	9.6	9.9	2.3	33.7	0.8	0.0	0.0	25.2	26.2	0.0	3.4	0.0	0.0	0.
〃 *tetrastichon* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	36.8	6.4	3.1	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.
〃 *rostratus* Lauder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
〃 *dadayi* Pavillard	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
〃 *spp.*	4.8	7.2	13.6	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	2.1	20.0	21.3	2.0	10.5	50.0	14.7	0.8	0.0	0.0	6.2	15.7	0.0	0.0	17.3	0.0	7.
Rhiz. styliformis Brightwell	1.2	2.6	8.1	6.2	14.9	7.1	0.0	22.2	50.0	32.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
〃 *styl. var. latissima* Brightwell	0.0	0.0	0.0	0.0	0.8	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
〃 〃 〃 *longispina* Hustedt	0.0	0.0	1.1	0.0	0.0	0.0	0.0	11.1	10.9	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.1	tr.	0.2	0.0	0.0	0.0	0.
〃 *acuminata* (Pérag.) Gran	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.2	0.0	0.0	8.2	15.7	[illegible]	17.0	8.4	7.4	10.7	0.
〃 *Castracanei* H. Péragallo	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.2	0.0	0.
〃 *alata* Brightwell	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	tr.	0.0	0.0	0.0	0.0	0.
〃 〃 *f. gracillima* (Cl.) Grunow	0.0	0.5	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.2	3.8	0.2	1.2	0.0	0.
〃 *cylindrus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.
〃 *hebetata f. semispina* (Hensen) Gran	0.2	0.0	0.0	3.0	7.5	3.6	3.4	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
Climacodium biconcavum Cleve	0.0	0.0	0.0	0.0	22.4	17.8	24.1	0.0	37.5	37.4	0.0	44.5	66.4	78.3	7.1	0.0	4.3	2.2	2.3	0.0	51.7	41.7	8.8	2.4	0.0	0.0	0.9	0.0	0.0	0.
〃 *Frauenfeldianum* Grunow	1.9	0.0	0.0	0.0	11.9	9.8	17.2	0.0	0.0	16.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.
Dactyliosolen tenuis GRAN	0.7	3.6	1.9	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.5	0.0	0.0	0.0	25.2	0.0	0.0	0.0	0.0	0.0	1.
Hemiaulus Hauckii Grunow	0.0	0.0	0.0	0.0	2.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	1.
Planktoniella sol (Wallich) Schütt	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
Thal'x Frauenfeldii Grunow	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	2.1	0.1	0.0	0.2	0.0	0.0	0.
〃 *longissima* Cl. & Grun.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
Bacteriastrum hyalinum Lauder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	4.7	0.0	8.5	0.0	0.0	2.2	5.7	0.7	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
Leptocylindrus danicus Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.
Licmophora abbreviata AGARDH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.

Appended Table 3 List of plankton species captured with Kitahara's net during the period Oct. 7–18, 1952.

St. No.	1	6	7	8	10	11	12	14	15	16	17	18	[illegible]	25	30	[illegible]	34	36	38	39	41	42	[illegible]
Latitude (N)	37°11'	37°23'	37°33'	[illegible]	37°40'	37°47'	38°00'	38°00'	38°17.5'	38°36'	38°53'	39°10'	[illegible]	39°09'	[illegible]	38°46'	[illegible]	38°07'	37°44.0'	[illegible]	[illegible]	[illegible]	[illegible]
Longitude (E)	137°10'	137°21.5'	137°18'	136°57.5'	136°59.5'	137°01'	136°45'	137°36'	137°49.5'	138°00'	138°10.5'	[illegible]	138°44.5'	[illegible]	[illegible]	[illegible]	137°10'	139°01'	[illegible]	136°24'	[illegible]	[illegible]	[illegible]
Date	Oct. 7	Oct. 7	Oct. 7	Oct. 8	Oct. 8	Oct. 8	Oct. 8	Oct. 8	Oct. 9	Oct. 9	Oct. 9	Oct. 9	Oct. 9	Oct. 9	Oct. 11	Oct. 14	Oct. 14	Oct. 14	Oct. 17	Oct. 17	[illegible]	Oct. 18	Oct. 18
Time	1020	1300	1510	0755	0925	1040	1340	2115	0050	0420	0750	1110	1420	[illegible]	[illegible]	[illegible]	1600	1920	1500	1800	[illegible]	1100	[illegible]
Total number of plankton inds./m³	279,650	126,680	2,727,004	1,010,857	2,434,975	596,194	822,409	483,521	548,090	436,849	303,902	213,367	276,391	731,279	341,130	[illegible]	[illegible]	827,645	1,246,494	795,087	[illegible]	[illegible]	[illegible]
Zooplankton																							
Number of zooplankton inds./m³	5,593	3,749	8,806	5,236	7,616	7,378	5,831	10,353	8,925	6,188	5,236	6,426	14,637	833	9,996	5,474	7,616	5,474	4,177	5,355	[illegible]	4,895	[illegible]
Percentage to the total plankton	2.0	3.0	0.3	0.5	0.3	1.1	0.7	12.2	[illegible]	1.4	1.7	3.0	5.3	0.1	0.7	0.8	[illegible]	0.7	0.3	[illegible]	[illegible]	0.8	1.1
Phytoplankton																							
Number of phytoplankton inds./m³	274,057	122,931	2,718,198	1,005,621	2,427,362	588,816	816,578	473,168	539,165	430,661	298,666	206,941	261,754	730,446	331,134	[illegible]	636,438	822,171	1,242,317	[illegible]	[illegible]	[illegible]	[illegible]
Percentage to the total plankton	98.0	97.0	99.7	99.5	99.7	98.8	99.3	87.8	98.4	98.6	98.3	97.0	94.7	99.9	99.3	[illegible]	98.8	99.3	[illegible]	[illegible]	[illegible]	[illegible]	98.9
Inclination of the wire of net (°)	11	40	45	27	35	46	40	45	40	50	44	40	53	45	51	[illegible]	[illegible]	47	45	45	[illegible]	[illegible]	[illegible]
Percentage to the zooplankton																							
Protozoa	8.5	22.2	18.9	[illegible]	6.2	8.0	8.2	17.2	[illegible]	11.5	2.3	18.4	15.4	7.3	13.1	[illegible]	[illegible]	[illegible]	12.8	4.4	4.0	4.0	4.6
Copepoda	29.8	11.0	13.5	[illegible]	24.9	24.1	16.2	18.3	22.6	15.4	25.0	20.5	18.5	15.9	42.9	10.9	20.4	13.0	[illegible]	[illegible]	4.0	[illegible]	[illegible]
Misc.	12.7	8.8	18.9	[illegible]	15.6	[illegible]	18.3	10.3	9.3	1.9	2.2	12.9	16.9	10.0	8.3	4.3	10.9	10.8	5.2	11.1	[illegible]	[illegible]	7.3
Larval forms	48.9	57.7	48.6	[illegible]	53.2	58.3	57.1	54.0	57.3	71.2	70.5	48.1	49.2	65.8	35.7	65.3	[illegible]	69.5	76.8	[illegible]	[illegible]	[illegible]	[illegible]
Percentage to the phytoplankton																							
Cyanophyceae	0.4	0.0	0.0	0.2	0.1	0.7	0.4	0.5	0.0	0.0	0.0	0.0	0.9	2.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dinoflagellata	2.0	2.5	0.7	3.5	0.3	0.6	0.8	2.1	1.4	1.1	1.2	3.7	4.5	1.5	1.3	2.8	1.9	1.1	0.9	1.1	1.1	[illegible]	1.6
Diatomaceae	97.6	97.5	99.3	99.3	99.6	98.7	98.8	97.4	98.6	98.9	98.8	96.3	94.6	96.5	98.5	97.2	98.1	98.9	99.1	98.9	[illegible]	[illegible]	98.4
Percentage to the phytoplankton																							
Trichodesmium	0.4	0.0	0.0	0.2	0.1	0.7	0.4	0.5	0.0	0.0	0.0	0.0	0.9	2.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Peridinium fatulipes Kofoid	tr.	tr.	0.1	0.0	0.0	0.0	0.0	tr.	0.0	0.3	tr.	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0
〃 *depressum* Bailey	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *oceanicum* Vanhöffen	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *Pellucidum* (Bergh) Schutt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	0.0	tr.	tr.	0.0	0.0	tr.	tr.	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Dinophysis homunculus Stein	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnodinium sp.	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acanthodinium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceratocorys horrida Stein	0.4	tr.	0.0	tr.	tr.	0.1	0.1	tr.	0.2	0.0	tr.	1.1	0.4	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
Triceratium sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cerataulina compacta Ostenfeld	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amphisolenia bidentata Schröder	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pyrocystis sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceratium massiliense (Gourr.) Jörg.	1.2	1.2	0.2	0.2	0.2	0.4	0.4	0.7	1.0	0.8	0.8	1.6	1.7	0.3	0.6	0.6	0.7	0.6	0.3	0.4	0.4	0.5	1.4
〃 *tripos* O. F. Müller	0.0	tr.	0.0	tr.	tr.	0.0	tr.	tr.	0.0	0.0	0.0	0.0	0.4	0.2	0.1	0.0	0.2	0.1	0.0	0.0	0.1	0.1	[illegible]
〃 *carriense* Gourret	0.0	0.0	0.0	0.0	0.0	tr.	tr.	0.2	tr.	tr.	0.0	0.0	0.4	0.2	0.2	0.0	0.2	0.1	0.1	0.1	[illegible]	[illegible]	0.0
〃 *extensum* (Gourr.) Cleve	tr.	0.0	0.0	tr.	tr.	tr.	tr.	tr.	0.2	tr.	0.0	0.0	0.4	0.2	0.1	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.0
〃 *macroceros* (Ehrbg.) Cleve	tr.	tr.	0.1	0.1	0.0	tr.	tr.	0.0	tr.	tr.	0.4	0.5	0.4	0.2	0.0	[illegible]	0.2	0.1	0.1	0.1	0.1	0.0	[illegible]
〃 *deflexum* (Kofoid) Jörg.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	[illegible]
〃 *Candelabrum* (Ehrbg.) Stein	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
〃 *pentagonum* Gourret	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *nipponicum* Okamura	0.4	0.0	0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chaet. densus Cleve	0.0	0.0	0.2	0.0	0.0	0.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]	0.9	0.4	0.0	0.0
〃 *borealis* Bailey	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
〃 *atlanticus* Cleve	0.0	0.0	0.9	0.0	1.4	0.0	0.0	1.2	0.0	0.0	0.8	0.5	0.0	0.0	0.0	0.6	0.0	2.2	2.7	0.0	0.0	0.0	0.0
〃 *coarctatus* Lauder	0.8	1.9	[illegible]	1.7	3.5	0.7	1.0	6.9	0.6	2.1	2.3	2.7	6.0	0.6	0.6	2.1	0.9	0.4	0.2	0.1	0.1	0.0	1.9
〃 *neapolitanus* Schröder	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	0.0	2.0
〃 *pelagicus* Cleve	3.7	2.5	5.5	5.2	9.1	2.5	3.6	4.5	2.6	4.9	4.1	1.6	6.4	5.4	2.6	2.1	4.6	3.4	8.3	0.0	1.0	0.0	4.1
〃 *peruvianus* Brightwell	3.3	3.2	2.1	2.1	1.4	2.5	1.9	2.4	1.0	2.3	3.0	2.7	1.3	0.8	1.3	1.8	3.9	4.8	[illegible]	3.0	[illegible]	[illegible]	1.9
〃 *Lorenzianus* Grunow	4.9	0.0	3.0	1.6	1.2	2.4	1.4	0.0	3.1	0.8	0.0	0.0	1.3	3.7	0.6	0.0	2.3	2.5	1.9	[illegible]	1.6	[illegible]	6.0
〃 *didymus* Ehrenberg	35.5	25.5	30.3	32.0	26.7	31.0	45.1	24.6	46.6	39.0	31.9	28.1	20.9	26.3	42.9	46.8	33.4	[illegible]	26.3	33.7	19.5	[illegible]	[illegible]
〃 *affinis* Lauder	2.0	0.0	0.3	1.6	0.0	1.7	0.4	0.7	0.0	0.8	0.8	0.0	2.1	2.9	0.9	1.8	0.9	1.0	5.2	0.0	0.9	0.0	3.3
〃 *compressus* Lauder	0.8	6.4	1.6	0.0	0.3	0.0	0.0	0.7	0.8	1.0	0.0	0.0	0.0	0.0	0.3	0.0	1.6	2.3	4.9	3.7	3.5	6.1	2.9
〃 *curvisetus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.3
〃 *pseudocurvisetus* Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	1.0	0.0	0.0
〃 *diversus* Cleve	0.0	0.0	0.8	0.6	0.8	2.5	0.4	0.0	0.4	0.0	0.0	1.6	0.0	2.1	2.1	2.6	1.0	1.6	6.3	3.1	[illegible]	8.6	2.4
〃 *brevis* Schütt	20.0	7.0	19.9	12.2	16.8	16.5	8.5	20.8	13.9	12.2	14.7	13.0	6.0	5.8	10.3	7.9	13.0	11.5	8.8	[illegible]	[illegible]	13.3	[illegible]
〃 *messanensis* Castracane	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.7	0.0	0.0
〃 *Eibenii* Grunow	0.4	0.0	0.0	0.2	0.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
〃 *tetrastichon* Cleve	0.0	0.0	0.1	0.2	0.0	0.0	0.0	1.4	0.0	0.8	1.1	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.5	0.4
〃 *spp.*	2.9	3.8	1.4	1.2	4.9	1.3	2.0	0.5	0.0	2.6	0.0	0.5	1.3	4.1	0.8	0.0	0.9	0.0	1.0	4.1	3.6	1.3	1.5
Rhiz. setigera Brightwell	0.0	0.6	0.1	0.2	0.1	0.0	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1
〃 *Bergonii* H. Péragallo	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0
〃 *robusta* Norman	0.4	tr.	0.0	tr.	0.0	0.0	0.0	0.0	0.0	tr.	0.9	0.0	0.0	0.0	0.1	0.0	0.3	0.1	0.0	0.0	0.1	0.1	0.0
〃 *Stolterfothii* H. Pérag.	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.0	0.4	0.1	0.0	0.1	0.0	[illegible]
〃 *cylindrus* Cleve	0.0	0.0	0.0	0.3	0.3	0.4	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0
〃 *alata* Brightwell	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
〃 〃 *f. genuina* Gran	0.0	0.0	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
〃 〃 *f. gracillima* (Cl.) Grunow	2.0	0.0	0.8	1.1	0.2	2.4	1.6	2.4	0.8	1.3	0.4	1.1	0.0	0.4	0.4	1.6	3.1	1.2	1.4	1.4	1.1	1.9	0.6
〃 *imbricata* Brightwell	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *Castracanei* H. Péragallo	tr.	tr.	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *hebetata f. semispina* (Hensen) Gran	2.0	6.4	2.3	4.0	2.7	4.5	5.9	5.9	3.5	4.1	4.6	10.8	3.9	1.4	2.3	5.1	4.2	3.1	4.0	2.3	3.2	1.4	0.0
〃 *styliformis* Brightwell	0.4	0.0	0.0	0.0	0.3	0.5	0.7	0.0	0.2	0.0	1.1	0.5	0.4	0.3	0.1	0.5	0.0	0.0	0.2	0.3	0.0	0.0	0.0
〃 〃 *var. latissima* Brightwell	0.0	0.0	0.0	tr.	0.1	0.1	0.0	0.0	0.0	0.3	0.4	3.8	0.4	0.0	0.7	0.8	0.2	0.0	0.2	0.1	0.1	0.0	0.0
〃 〃 *var. longispina* Hustedt	0.0	0.0	0.0	0.3	0.0	0.0	0.0	2.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *acuminata* (Pérag.) Gran	0.4	0.6	tr.	0.2	0.1	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *Calcar-avis* Schultze	0.0	0.0	tr.	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.4
Thallassionema nitzschioides Grunow	1.2	6.4	4.9	2.2	3.2	1.2	3.7	1.9	0.0	0.5	0.0	6.0	17.9	20.6	9.6	1.8	2.4	2.5	0.3	3.0	4.0	2.2	9.1
Thal'x Frauenfeldii Grunow	9.0	7.6	6.8	7.2	11.2	9.8	7.9	6.4	12.1	9.6	15.1	8.7	11.1	14.0	7.6	9.0	8.4	10.0	6.9	9.4	9.3	12.8	11.0
〃 *longissima* Cl. & Grun.	1.2	3.8	1.0	2.5	1.3	1.2	1.6	1.7	2.8	0.5	2.7	1.6	2.1	0.8	0.5	1.0	1.4	1.2	1.9	2.4	1.7	1.6	1.4
Thal'sira subtilis (Ostenfeld)	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Clymacodium biconcavum Cleve	3.3	0.6	0.8	0.7	0.5	1.5	1.2	3.3	3.0	1.3	4.1	4.9	0.0	0.3	0.2	0.8	3.2	2.6	0.5	1.0	0.9	0.0	0.0
〃 *Frauenfeldianum* Grunow	0.0	3.2	0.4	0.9	0.5	0.5	0.6	0.0	0.8	0.3	4.6	0.0	0.0	0.0	0.0	0.0	5.4	0.7	0.0	0.4	0.0	2.3	0.0
Streptotheca indica Grunow	1.2	3.8	0.0	4.7	1.0	4.1	0.0	1.7	1.0	8.3	0.8	1.6	6.8	1.2	2.6	0.6	0.7	2.0	2.5	3.7	0.2	0.1	0.0
Nitzschia seriata Cleve	0.0	0.0	1.8	0.4	0.0	0.4	0.7	0.0	2.0	0.0	0.0	0.0	3.4	0.0	0.9	0.0	0.7	0.0	3.6	3.0	3.1	2.5	3.8
Hemiaulus Hauckii Grunow	0.0	0.0	0.0	0.0	1.2	0.0	1.1	3.6	0.0	0.5	0.8	1.6	0.0	0.0	1.0	1.6	0.0	0.0	0.2	0.6	1.3	0.0	0.4
Asterionella japonica Cleve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0
Bacteriastrum hyalinum Lauder	1.2	9.6	5.1	2.2	5.4	7.2	4.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.4	0.3	6.1	7.2	14.1	7.2	0.0
〃 *varians* Lauder	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	2.6	2.3	3.8	0.0	0.0	0.1	2.4	0.7	0.0	0.0	0.0	0.0	0.0	7.1
Leptocylindrus minimus GRAN	0.0	1.9	8.4	3.1	3.7	0.8	1.4	0.2	2.2	1.8	1.9	1.1	1.7	3.2	3.0	4.7	0.7	1.2	0.8	0.0	0.6	0.9	1.4
Dactyliosolen tenuis GRAN	0.0	2.5	0.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	1.5	0.5	0.4	2.2	0.9	0.0
Skeletonema costatum (Grev.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biddulphia sinensis Greville	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0
〃 *aurita* (Lyngb.) Breb.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	tr.	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Ditylum Brightwellii Grunow	0.0	0.0	0.0	0.0	0.1	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.2	0.1	0.1	0.1	0.3	0.5	0.1
〃 *sol* Grunow	0.8	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lauderia borealis Gran	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Corethron hystrix Hensen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleurosigma	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.0	0.0	0.0
Melosira	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eucampia cornuta (Cleve) Grunow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percentage to the zooplankton																							
Noctiluca scintillans Macartney	6.4	8.9	5.4	2.3	3.1	3.2	4.1	2.3	2.7	5.8	2.3	5.5	3.1	1.5	0.0	6.5	1.6	2.2	7.7	0.0	2.0	0.0	2.4
Globigerina bulloides d'Orb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.3	1.9	0.0	3.7	0.0	2.9	1.2	4.3	0.0	2.2	0.0	0.0	0.0	2.0	2.4
Sticholonche zanclea Hertwig	2.1	13.3	13.5	0.0	3.1	4.8	4.1	12.6	6.7	3.8	0.0	9.2	12.3	2.9	11.9	8.7	9.3	0.0	5.1	2.2	2.0	0.0	0.0
Radiolaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Tintinnus perminutus sp. niv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0
〃 *tenue* sp. nov.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	tr.	0.0	0.0	0.0	0.0	0.0	tr.
Rhabdonellopsis sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
Codonellopsis sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0
Calanus helgolandicus (Claus)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mecynocera clausi Thompson	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Paracalanus parvus (Claus)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	2.3	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acrocalanus sp.	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.6	0.0	0.0	2.2	0.0	0.0	0.0
Clausocalanus furcatus (Brady)	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *pergens* Faran	2.1	0.0	0.0	0.0	0.0	0.0	2.0	4.6	0.0	0.0	0.0	3.7	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *arcuicornis* (Dana)	6.4	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	9.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *sp.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	1.9	6.2	0.0	4.8	4.3	1.6	0.0	0.0	0.0	2.0	0.0	3.7
Temora discaudata Giesbrecht	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Acartia danae Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0
Lucicutia flavicornis (Claus)	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Oithona similis Claus	0.0	0.0	2.7	0.0	0.0	0.0	2.0	0.0	4.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Setella gracilis Dana	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Microsetella rosea (Dana)	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	0.0	0.0	2.2	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
〃 *norvegica* (Boeck)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	4.3	2.6	8.9	0.0	7.8	1.2
〃 *sp.*	8.5	0.0	8.1	6.8	3.1	3.2	4.1	3.4	2.7	0.0	6.8	5.5	6.2	4.3	3.6	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0
Clytemnestra sp.	2.1	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Oncaea media Giesbrecht	4.3	[illegible]	2.7	2.3	3.1	8.1	2.0	7.0	5.3	0.0	4.5	0.0	1.5	4.3	0.0	2.2	1.6	0.0	0.0	0.0	0.0	0.0	[illegible]
〃 *conifera* Giesbrecht	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *venusta* Philippi	6.4	0.0	0.0	0.0	3.1	4.8	0.0	0.0	0.0	0.0	2.3	1.9	0.0	2.9	0.0	0.0	6.2	2.2	2.6	0.0	0.0	9.8	1.2
〃 *spp.*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corycaeus concinnus Dana	0.0	2.2	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *gibbulus* Giesbrecht	0.0	2.2	0.0	4.5	0.0	3.2	4.1	0.0	1.3	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
〃 *japonicus* sp. nov.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	3.1	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
〃 *agilis* Dana	0.0	0.0	0.0	2.3	3.1	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.2
〃 *sp.*	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.8	0.0	0.0	0.0	2.9	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	1.2
Lucifer raynaudii Bate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Penilia schmackeri Richard	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.9	2.4	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
Podon sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Evadne tergestina Claus	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Doliolum nationalis Borgert	0.0	2.2	0.0	0.0	3.1	0.0	2.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Medusae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0
Fritillaria haplostoma Fol.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Oikopleura spp.	10.6	4.4	10.8	6.8	9.4	9.7	10.2	10.3	5.3	1.9	2.2	7.4	10.8	7.1	1.2	0.0	3.1	4.3	2.6	8.9	2.0	3.9	3.7
Sagitta spp.	2.1	2.2	8.1	9.1	3.1	0.0	6.1	0.0	2.7	0.0	0.0	5.5	4.6	0.0	4.7	4.3	6.2	6.5	2.6	2.2	0.0	7.8	1.2
Nauplius larva	23.4	24.4	18.9	36.4	21.9	30.7	22.5	19.5	20.0	15.4	18.2	14.8	15.4	26.9	14.3	32.6	10.9	23.9	23.0	8.9	30.6	7.8	18.3
Calanidae juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.8
Eucalanus juv.	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calocalanus juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gymnoplea juv.	6.4	15.6	13.5	11.3	15.6	14.5	18.4	11.5	6.7	25.0	25.0	14.7	12.3	19.8	4.7	13.0	18.7	26.1	23.0	26.7	8.2	27.5	0.0
Temora juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
Clytemnestra juv.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
Corycaeus juv.	0.0	4.4	2.7	2.3	0.0	1.6	2.0	2.3	0.0	0.0	0.0	0.0	3.1	0.0	4.8	0.0	0.0	0.0	5.1	2.2	0.0	0.0	0.0
Oithona juv.	2.1	13.3	0.0	0.0	0.0	1.6	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	4.8	2.2	1.6	4.3	0.0	4.4	4.1	0.0	1.2
Oncaea juv.	12.8	0.0	10.8	6.8	6.3	9.7	10.2	8.0	28.0	28.9	25.0	11.1	12.3	12.8	0.0	10.9	25.0	4.3	17.9	29.0	10.2	15.6	0.0
Cirripedia nauplius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gastropoda larva	2.1	0.0	0.0	0.0	0.0	0.0	0.0	7.0	1.3	0.0	2.3	1.9	0.0	4.3	0.0	0.0	1.6	6.5	2.6	0.0	28.6	5.9	9.8
Polychaeta larva	0.0	0.0	0.0	0.0	3.1	0.0	0.0	1.1	1.3	0.0	0.0	0.0	1.5	0.0	1.2	4.4	0.0	0.0	2.6	0.0	6.1	0.0	2.4
Pelecypoda larva	0.0	0.0	2.7	0.0	6.3	0.0	2.0	2.3	0.0	0.0	0.0	3.7	0.0	1.5	4.7	0.0	0.0	0.0	2.6	0.0	2.0	3.9	0.0
Ophiopluteus larva	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pisces egg	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

日本海の海況及び水系

—— 1955年夏を中心として ——

下村敏正・宮田和夫

The Oceanographical Conditons of the Japan Sea and Its Water Systems, laying Stress on the Summer of 1955

by

Toshimasa SHIMOMURA and Kazuo MIYATA

目次

第1章 1955年8月における日本海海況の一般

Chapter I A General Review of the Sea Conditions of the Japan Sea in August, 1955.

I はしがき

日本海の大半を被う大規模な海洋観測は，table 1 の如く，1930年以来10回に及んでいる。戦後の観測は，海上保安庁水路部・日本海区・北海道区の両水産研究所・舞鶴及び函館海洋気象台・各道府県水産試験場によつて，戦前に勝る活潑さを以て実施されつつある。

Table 1 Large-scale oceanographical observations carried out in the Japan Sea.

年	月	観測実施機関	観測区域
1930	6〜9	神戸海洋気象台他（春風丸）	日本海全域
1932	5〜6	農林省水産試験場他（蒼鷹丸）	〃
1941	5〜6	○ 〃 （ 〃 ）	〃
1943	8	水路部（富山丸）	〃
1946	8〜9	○ 〃	マ・ライン以南の全域
1948	7〜9	○ 〃	〃
1949	8	○ 〃	〃
1955	8	○日本海区水産研究所他（蒼鷹丸）	E132° 以東の全域
1956	3〜4	〃 （天鷹丸）	大和堆以東の全域
1956	8〜9	〃 （蒼鷹丸）	対馬〜奥尻島

（○印は第2章に用いた資料）

ことに，昭和28年水産庁の国庫補助による '対馬暖流開発調査' が実施されるようになつてからは，日本海のみならず，南は台湾から北は樺太までの対馬暖流の全域にわたる観測が実施され，毎月初日を以て出港とする，少なくとも月一回の '一斉観測' 的なデータが集積されつつある。結果として対馬暖流の物理・化学的な周年変化のみならず，プランクトン・魚卵・稚魚・魚道等々に関する知見は飛躍的に増大した。単に海洋学的知見のみならず，プランクトン・魚卵・稚魚及びサバ・スルメイカ・イワシ・ブリ・アブラツノザメ・底魚などの重要魚種についての生物学的・生態的・漁業的知見もまた飛躍的に増大した。

しかし前記の大観測にせよ，対馬暖流開発調査にせよ，前者には日本海中央部に未観測域の広いこと，後者には，例えば日本海では距岸 100 浬以沖の調査が全く行なわれていないことが盲点となつている。それは日本海における海況・漁況・生物学的な資料が揃つてくると共に，その盲点を衝く必要性が痛感されるようになつてきた。特にあらゆるものを綜合して成り立つ漁況予報の内容が詳細化すればする程，日本海の全域にわたる詳細な観測が要求されてきた。

そこで筆者等は予算及び配船計画の許す最大限の範囲内で，昭和30年3月竣工の新鋭船蒼鷹丸（258屯，500 HP）により fig. 1 のコースにより，下記要領に従つて観測を実施した。

1. 調査の目的

i) 大羽イワシなどの漁況予報に最も重要な手段である，佐渡沖冷水域の垂直的，水平的の基をさぐる（日水研）

ii) スルメイカの沿岸群と沖合群との関連の調査及び夏期におけるサンマ群の所在の調査（日水研）

iii) 従来日本海の基本的水質としては，水温・塩分が主体となつているので，O_2・栄養塩類などの化学成分を3,000m.深まで調査する（東大・日水研）

iv) 沿岸・沖合を通ずる魚卵・稚魚・生物の生態調査（日水研）

v) plankton・Euphausia の分布調査（日水研・東大）

vi) 暖流調査のシンポジウムで常に論議される plankton・稚魚採集法の研究— 1,000m 深まで（北大・日水研）

vii) 海水懸濁物の研究（北大）

2. 調査項目

i) 日水研関係の分

a：観測水深（m.）

0・10・25・50・75・100・150・200・300・400・500・600・800・1,000・1,500・2,000・3,000

b：観測項目

イ．水温・塩分・酸素量・PH・水色・透明度・海面状態・気象

ロ．plankton・魚卵・稚魚

ハ．plankton などの垂直分布に関連して菱田式照度計による，海中照度の測定（50m深まで）

ニ．10,000m極深海用音響測深儀による海底地形及び dredge による海底地質の調査

ホ．海流瓶の投入（各 st. 20本とし計1,000本）

ヘ．イカ・サバ・サンマの生態調査

ii) 東大関係の分

a：海水の化学的精密分析

SiO_2—Si・P_2O_5—P・HNO_2—N・HNO_3—N・NH_3—N・・alkalinity・PH

b：Euphausia の分布・生態調査

iii) 北大関係の分

a：plankton などの採集法の研究

イ．depressor による，1,000m. 深までの plankton・稚魚の水平曳採集

ロ．航走採集器による表層 plankton の採集

b：海中懸濁物の採水採集

c：表層曳用 thermister による測温

3. 調査員

i 8月12日〜16日（八戸→函館→新潟 st. 1〜13）

日水研：下村敏正・長沼光亮・名筋一宗

北　大：安楽正照・西沢敏（函館港より便乗）

ii 8月19日〜23日（新潟⇄沖合 st. 14〜27）

日水研：永田俊一・向井茂・名筋一宗・永原正信

北　大：安楽正照

iii 8月26日〜9月1日（st.28〜44〜船川）

日水研：下村敏正・向井茂・長沼光亮

東　大：松江吉行・小牧勇蔵・村野正昭

以上の内，ここには日水研・東大の分のみを掲載する。北大の分は同大学から別途発表されるはずである。

今回の観測は，観測の末期（8月29日以降）には瞬間風速25m./sec. 以上にも及ぶ暴風雨の中を強航したため，

北海道奥尻島西方の海域は欠測の止むなきに至つたとは言え， E132°〜N41°40′， すなわち西は島根県浜田港の緯度線まで，北はソ連 Povorotnuii 岬を距る50浬の地点までの広域の観測であり，引き続いて発表予定の昭和31年春の天鷹丸による北部日本海の沖合調査，及び8〜9月に蒼鷹丸による奥尻島〜対馬間の日本海全域の調査の前駆をなすものである。近年戦後における日本海の全般的な暖候化・イワシ・サバなど暖海性魚族の漁場の北漸，逆に北海道西岸におけるニシン漁の不漁化，その他漁況・海況の日本本土と北海道との相反する現象・浮游機雷の本土への漂着状況の突然の変化等々の解明に実証の第一歩を与えた画期的な意義を持つものと信じている。もちろんそれ等に対する海況的な原因は既往の資料， その他の事実から想像はされていたし，現在からふり返つて見ても誤まつた判断はしていなかつた。しかし直接的な実証はなかつた。この意味で，本文は次の機会に発表する，1956年春，同8〜9月の観測と一体をなすものである。この意味で本文は，まず観測から得られた data に基いて， 物理・化学的な面からの一般的海況を詳細に記載し， しかる後に諸冷水塊の海洋学的解析，大和堆附近の海況の特性，plankton から見た水系の分析など個々の事象に触れいきたい。

4. 謝　　　辞

観測に当り多大の御援助を戴いた東大教授松江吉行博士， 蒼鷹丸船長今村喜市技官，及び困難な諸種の海上作業に終始御協力下さつた同船乗組員の方々に対し深甚の謝意を表します。なおこの報告は，下記の如く日水研開発部員諸氏の協力の下にできたことを記して深甚の謝意を表します。

海水の化学分析　：　町中茂・永原正信・長沼光亮・樋口喜代子
温度・深度補正　：　町中茂・長沼光亮
海流等の理論計算　：　永原正信
製図　：　町中茂・長沼光亮・永原正信・名筋一宗・樋口喜代子

なお，水温及び塩素量の水平分布図の作製に当つては， 各地方水試・第八管区海上保安本部の観測値を援用した。併せてここに謝意を記します。

Ⅱ 水温・塩素量の分布

1. 水温・塩素量の水平分布

0m. 層 (fig. 2)：ここ数年来の日本海の高温化は，今だに衰えず，本年は沿岸は別として，N30°30′以南は全域にわたつて，>25°Cの高温域となつている。最高は若狭湾経ケ岬寄りの 28.8°C.，最低は st.42 の 15.0°C.である。この 25°C. isotherm の位置は， 1953年より高温であつた1954に比べても，佐渡北方で 120浬，能登北方で180浬，隠岐島北方で 250浬も北に位置している。すなわち，20°C. isotherm は東西方向に走り，従来の如く本土海岸線に平行に走る傾向は見られぬ。このことは，日本海における対馬暖流（日本側から第1分枝・第2分枝・第3分枝と命名する）の内，沖合分枝たる第2，第3分枝の強勢化， 及び流路の変化すなわち日本本土の海岸線に平行に北東流する従来の法則を突き破つて，緯度線に平行に東へ流れ， 沖合から直接津軽海峡方面に向かうようになつたという， 対馬暖流調査史上嘗つてない変化の一斑を現わしたものと思われる。この点については別に発表する。要するに，全般的に見れば，南高北低， 沿岸高沖合低の水温分布を示す。数値的にいえば，能登半島を境にして以西は27°C. 以北は26°C. の海域であり，N 41° に Liman Front (polar front) が形成されている。

塩素量 (fig. 3) は，18.28 (st. 29)〜18.93‰ (st.18) の間に変移するが，

（1） 能登北方を NE に北上する<18.7 Cl‰の低鹹部

（2） 大和堆も含めて，その沖を NE〜N の方向に走る>18.80 Cl ‰の (33.964‰) 高鹹部

（3） さらにその沖を，北方から SE 方向に日本本土に向かう<18.70 Cl‰(33.784‰)の低鹹部

以上3者が印象的であるが，これらは同じ東海表層水に被われながらも， 混合によりそれぞれその下にある対馬暖流の第1分枝・第2分枝（対馬暖流の本流）・Liman 海流系水の存在を示している。

10m. 層 (fig.4)：いわゆる対馬暖流域では，10m. 層は表層流であるため，0m. 層と同様に分布を考えてよいのであるが，N40°30′ を越えると Liman 寒流域となるため， 第1躍層は 10m. 層を中心として存在するようになるので，ここにとり上げることとする。

暖流域内では，25°C. isotherm はE138°以西で SWに屈曲し，今回の観測範囲内では，対馬海峡にまで初めて出現するようになる。その走向は本土海岸線に平行となる。

水温は11.05° (st.31) ～27.6°C.(経ケ岬N 15浬) に変異するが，大和堆以北海域が 0m. 層と比較ならぬ位の複雑性を呈する。特に大和堆北縁の 12.53°C, st. 37 の 11.05°C. を中心とする冷水域及びこれらの間に介在する暖水域のため isotherms が複雑化されており，この方面の暖寒両流の接触面の複雑さを現わしている。この両 st. の水温の垂直変化は table 2 表のように甚だしく，st.34•37の5m. 層とその直下の層との 1m. 当りの温度傾度は，それぞれ 2.65°C. /m., 2.67°C. /m. という大きな値となる。これら両冷水域の内，前者は後に別記する如く，大和堆（最浅部は230m.）によりひき起された地形性湧昇流に因るものであり，後者は Liman 系水の南端部と暖流表層水との間に形成された Liman Front による躍層である。そして後者 (st. 37) を越えて，さらに大陸に近ずくと，水温は再び上昇に転ずる。

Table 2. Water-temperature and salinity at various depths of st. 34 and st. 37.

st. 34			st. 37		
Dep. (m.)	W.T.(°C.)	Salinity(‰)	Dep. (m.)	W.T.(°C.)	Salinity(‰)
0	25.4	33.838	0	24.6	33.567
5	25.75	〃	5	25.68	33.621
12	7.24	34.072	11	9.69	—
26	6.05	〃	25	3.64	34.018
51	4.40	〃	50	1.43	34.054
75	3.42	〃	80	1.35	34.072
100	2.55	〃	103	0.78	34.054
454	0.19	34.096	459	0.10	〃
651	0.08	〃	738	0.09	34.072

他にも隠岐島方面に，21.72°C.を中心とする冷水域の頭が見られるが，これは後に冷水域の項で一括して述べることとする（第3章参照)。

塩素量 の分布は，0m. 層と同様で，本土側ではやはり N39° 以南が <21.4‰の低鹹であり，入道埼W沖にも依然として低温・低鹹域が存在しているが，大和堆 NW 方向の Liman 系低鹹部の SE 方向への勢力の伸張が目立つ。table 2 から見られるように，st. 34・37 では塩分においては，水温の場合程著しい垂直傾度はない。これは明らかに高鹹の中核水を欠いだ，比較的低鹹の暖流表層水が，低鹹の Liman 系水の上に乗つているためである。すなわちこの方面の暖流の厚さは僅か数m. にすぎない。

25m. 層 (fig. 5)：Liman Front 以南の暖流域では，25m. 層が第1躍層となつている。25m. 層になると，暖流・寒流共にその流動状態がはつきりしてくる。

水温は，3.64°C. (st.37)～27.22°C.（若狭湾）の間に変異し，> 25°C. 域は一挙に佐渡以西の沿岸部に圧縮され，>27°C. 域は若狭湾奥に局限されてしまう。南北方向に見れば，0～10m. 層に比べて200浬の南退である。<10°C. の北方冷水域の南下状況もはつきりして，E134°30′・E136°線に沿う2派となつて南下している。大和堆北縁の湧昇性冷水域は相変らず顕著であるが，0～10m. 層にその存在が認められた隠岐西方及び若狭湾沖の冷水域は，さらに明瞭にその存在を示すようになる。入道埼沖冷水域も可なり明瞭に現われるが，これは10～25m. のみに存在する非常に弱いものであり，50m. 以深では全く消失する。

塩素量 (fig. 6) はこの層に至つて初めて19‰以上の高鹹域が現われるが，'垂直分布' の項で後述するよう (30頁) に，st.32 の>19.0 Cl ‰ (34.325‰)域は，対馬暖流（第2分枝）の中核水の頭であり，st. 35 のそれは第3分枝の，また N39° 以北沿岸部のそれは第1・第2分枝の中核水の頭を示すものに外ならない。北方 Liman 系水の塩分は，本土のごく沿岸部と同様に<18.80 Cl‰ (33.964‰) であり，0～25m. 中この25m. 層が海域的塩分差が一番小さい。

50m. 層 (fig. 7)：この層の水温などの分布は，日本海における対馬暖流中層水の流動を知る上に最も重要であり，深さによる塩分差の少ない対馬暖流域においては，50m. 層の水温分布さえ知れば暖流の大勢を知ることができる。それは parallel solenoid の理論が第一近似として適用されるからである（須田晥次:1932)。

秋田以南の沿岸部は，島根県地蔵岬東方の局部的な> 25°C. 域を除きすべて 20°C. 台となり，25m. 層で見られた >25°C. 域は全く消失してしまう。Liman 系水は，E134°30′・E136°・E138°30′ の経度線に沿つて見られるが，周囲の低温化と共にあまり目立たなくなつている。隠岐西方の冷水域は，ますます接岸の度を強めているが，若狭冷水域は，南下するというよりむしろ東西に幅を拡げている。

5～15°C. isotherms の密集部は，50m. 層における Liman Front の位置を示すものであるが，N40° の北と南とでは，多少その性質を異にする。すなわち，

1) N40° 以南では，isotherms は NE→SW の方向に走り，かつ全海域にわたつて>5°C. となつていて，Liman Front が東西方向に延びている。すなわちこの海域は，いわゆる対馬暖流域である。

2) しかるに N40° 以北では，isotherms は，N→Sの方向に走り，以南よりも著しく低温となつていて，暖流中層水塊が Liman 表層水塊の影響を受けている。

塩素量(fig.8)は，18.78‰～19.14‰の間に変異し，0～25m. の場合とは逆に，沿岸高沖合低の分布となる。けだし東海，黄海及び日本沿岸に由来する低塩分の表層水の影響が，全く除かれた中層水塊としては当然のことである。isohalines も大体 isotherms と平行して走るが，海域差が少ないため isotherms 程には，等量線は密集しない。しかし本土寄りと st. 38とに >34.325‰ (19.0 Cl‰) 域が明瞭に現われ，それらの中間海域は <34.145‰ (18.9 Cl‰) の低塩域となつている。そして st. 38 を越えて大陸に近ずくと，<33.964‰ (18.8 Cl‰) の最低鹹域となる。この低鹹域は Liman 系水であり，25m. 層にも見られるとおり，津軽海峡西口の低鹹域に連続するものである。そして対馬暖流よりも高比重の Liman 系水が，前者の下に斜めに潜入したものである。しかしこの Liman Front は深さと共に本土に接岸することなく，大体この附近 (N 40°・E139°) に安定している。すなわち鉛直面的な front となつている。

そしてこれらの内，日本寄りの広大な高鹹域は暖流第1・第2分枝の中層水を示すものであり，st. 38 の高鹹部は，第3分枝が大和堆西方で分枝したものと思われる。これら両高鹹域の間に介在する低鹹域は，低鹹な Liman 系水の影響を受けて生成されたものである。

最高鹹部は山形県加茂沖の 19.1 Cl‰ (34.506‰) 域であるが，今回及び7月上旬同方面における山形県水試の観測中，どの層にも，またどの st. にも見られない高値であるため，その由来は恐らく，本観測と7月上旬観測期日との中間の期間に，高鹹水塊として南部日本海から北上して来たものであろう。これは75m. 以深では消滅する。

ところで，50m. 層の水温分布を，ちようど夏期に比較的沖合まで観測された昭和21・23・24・27年のそれと比較すると，近年日本海，特に北部日本海が高温化しつつあることが明らかである。昭和23年8月では，津軽海峡西口に接近して<2°C. 域が顕著に現われているが，30年8月では 5°C. 台域となつていて，同方面の 2°C 域は，さらに 100m. 下の 150m. 層に至つて初めて現われる。これは同方面における冷水域の本土への接岸勢力の弱化であり，日本本土の全般に通じて言えることである。

75m. 層：50m. 層とほとんど同様の分布であるが，50m. 層では秋田南部にまで及んでいた 20°C. isotherm は，一挙に 200浬も南退して経ケ岬以南の，しかもごく沿岸部に圧縮される。そしてこの>20°C.域は，E130° meridian に沿う若狭沖冷水域の強勢な南下による経ケ岬到達に因り，ここで両分される。

水温範囲は，1.24° (st.38) ～22.84°C. (鳥取地先) であるが，隠岐西方の冷水域はますます強く，浜田に向かつている。水温分布で最も著しいことは，隠岐海域における対馬暖流中層水の沖合への張り出しが極めて強く，各層中 N—S 方向の幅が一番広くなつている。も一つは，0m. 層からずつと出現していた入道埼沖の高温域である。すなわち，対馬暖流の N から E への転向点であり，高温・高鹹水の沈降流によつて形成されたものであるが，100m. 以深では消失してしまう。

塩分の分布も 50m. 層とほとんど同様であるが，ただ 50m. 層では，加茂沖に局部的に存在するにすぎなかつた >19.1 Cl‰ (34.506‰) の最高鹹域が，能登半島にまでも南延したことが目立つている。また N40°・E137°の >19.0 Cl‰ (34.325‰)域は，50m. 層における 19.0 Cl ‰線の突出先端部が沈降して，とり残されたものである。

100m. 層：水温(fig. 9) は0.85°(st. 37)～20.64°C. (鳥取沖)に変異するが，山口県附近を除き>20°C. 域は鳥取沖に局部的に存在するのみであり，N39° 以南の沿岸部はすべて 15°C. 線を以て被われる。各冷水域は依然明瞭であるが最低温域 (<0.1°C.) は N41° 線に沿つて存在し，一見これが源泉となつて佐渡へ向かう冷水域の根元らしく受けとれる。しかしこれは figs. 37・49・figs. 21・22 から判るとおり，低酸素量の日本海底層水が湧昇してきて，Liman 系水と混合したものであり，むしろ底層水が主体をなしている。isotherms の密

集は，大和堆西縁～西南方に特に甚だしく，100m. 層において，これより以浅の東流が急に南流に転ずるという90°の方向転換を見せている。すなわち，大和堆附近における深層水の強い地衡流（geo-strophic current）により誘起されたものである（第３章 日本海における主要冷水域の海洋学的考察参照）。

塩素量（fig. 10）の分布は，単に暖流域と寒流域とに両分できるのみで st. による塩分差が非常に小さい。例えば，沖合寒流域の広大な海域は到る所 18.86 Cl‰（34. 072‰）前後である。

150m. 層：15°C. 域は全く消失し，鳥取～秋田の中部日本海沿岸部が，僅かに>10°C. の最高温域となる。<1°C. 域は N40°～42° 一帯に拡延する。隠岐島西側に>10°C. 域があるが，これは 100m. 層において，隠岐島で２分して沖合へ向かう暖流中層水の西側分枝の沈降流である。又経ケ岬における，7°C. を中心とする低温域は，若狭沖冷水域の地形性湧昇流を示すものに外ならない。能登半島の陸棚によつて分離された西側・東側の最高温域（>10°C.）も，暖流の沈降に因るものであり，この内の西側高温域は 200m. 層では，隠岐北方からの冷水域により消失する。

150m. という深さでは，対馬暖流が低塩分の深層水と混合し始める，いわゆる第２躍層があるので，塩分は全般的に低下し，全 st. にわたつて<19.0 Cl ‰（34.325S‰）となる。また寒流域・暖流域共に st. による差がごく少なくなり，前者は 18.86 Cl‰（34.072S‰）前後に，後者は 18.99cl‰（34.307S‰）に一定する。

200m. 層：150m. 層と並んで，対馬暖流の第2躍層，すなわち暖流中層水が深層水或は低酸素の Liman 中間水との接触面である。この層では，水温（fig.11）は 0.44°（st.38)～10.47°C.（浜田沖）に変異するが，次の諸点が特徴として挙げられる。

1） 隠岐冷水域に代つて，隠岐島 NW 沖からの沖合冷水域が，島根～能登西岸に一様に拡がつてきた。
2） このため能登西方沿岸部の高温域は消失したが，代つてその沖合に，10°C. 台を中心とする広い高温域が出現し，300m. 以深にも明瞭に存在している。この高温域は，昭和25年（1950）に初めて出現したもので，以来冬期にも存在する非常に安定した高温域である。そしてこの高温域の出現は，25年以来沖合暖流の流路が急変したことと関係があり，３月の最低温期においても，300m. 層で 8°C. という高温を示す。今回の観測では，ちようどここが暖流第３分枝の域内にあり，この方面によく発達する時計廻りの環流により，150m. 層における能登西方沿岸部の高温域に由来するものと考えられる。
3） 一番大きな特徴は，0～150m. では，N40° において E135°・E136° の 2 meridan に沿つて，２分して南下していた沖合冷水域が，E136° に沿う一本に合体して能登陸棚に及ぶようになつたことである。200m. 以深では，各層とも常にこのように一本化されている。

この 1°C. 線は，暖流域と Liman 域とのなす Liman Front であり，この isothermを境にしてLiman 中層水の暖流下への急激な潜流が見られる（諸断面図参照）。

塩素量（fig. 12）：暖流域を示す 18.90 Cl.‰台域（34.325S‰）は，ますます本土沿岸に圧縮されるが，冷水域内は，やはり 18.86 Cl.‰（34.072S‰）前後に一定している。

300m. 層：水温変異(fig.13)は 0.26°（st.39)～8.46°C.（若狭湾沖）の範囲内にあり，水平的の海域差はますます減少する。

能登西方の沖合高温域は，5°～8.46°C. となつて，依然広い海域を占めているが，他はすべて <5°C.で，<1°C. 域はその範囲がいよいよ大きくなる。そして，150～200m. ではSE，すなわち能登へ指向していた能登冷水域は，300m. 層に至つて再び 0～100m. と同様に東方，佐渡へ指向するようになる。

isotherms の密集部は隠岐島北部に顕著である 若狭湾以西の沿岸部は，可なり広い<1°C. の低温域及び秋田沿岸に<2°C. の低温域が見られるが，地形性湧昇流によつて形成されたものである。そして沖合の<1°C. 域の中でも，よくみると st.41～43 では 0.5°C. 台で高温部をなしており，低温部はやはりそれよりも西方にある。

塩素量（fig. 14）においても，対馬暖流の影響はほとんど見られなくなり，>18.90‰域（34.145S‰）は加茂地先に局部的に現われるにすぎない。入道埼冷水域は，0m. 層から引き続いて<18.80‰域（33.964S‰）となつており，この値は 2,000m. 以深に至つてもなお存在する。この域の垂直断面図（fig.30）を見ると，0m. から 2,000m. に至るまで< 18.80‰域が強勢に存在している，このような，深層に至るまでの一定不変の値の存在は，過去において見られなかつた現象であるが，この域は Liman 系深層水の湧昇域であると共に，7.0cc

./l. 或いは8.0 cc./l. 以上の高酸素量水塊と，<6.0 cc./l. の低酸素量水塊との複雑な混合域 (fig. 57) であり，かつ<0.1kt. 以下（計算値）の弱い北上流の西側に接して存在する南下流との，接触面でもある。従つてこの深層にまでも及ぶ柱状の低鹹域は，北上流（暖流）と南下流（冷水塊）との，垂直的な接触面においてひき起された時計廻りの，ごく緩い，しかも安定した円筒状の水塊として存在するものと思われる。

この円筒水塊に連なつて，1,600m. 以深にも<18.80‰の低鹹域があるが (fig. 30)，これは純然たる深層水であつて，別物と思われる。

400m. 層：温度範囲 (fig. 15) は 0.18°C. (st.40) ～1.10°C. (st. 14) と，ますますその範囲が狭まつてくる。観測海域の大部分が<0.5°C. となり，>1.0°C. 域は，暖流の時計廻り環流による沈降に基く，加茂 W沖に僅かに見られるにすぎない。最低温域は津軽海狭西沖の，東西に連なる，帯状の 0.1°C. 台域であるが，これより更に北すると，ごく僅かながら再び高温域 (0.2°C.台) となる。

深層水と沈降暖流との拡散・混合はますます大きく，最低鹹 (fig. 16) の入道埼沖冷水域の影響は，能登にまで及ぶようになる。最高鹹部は最高温部（加茂沖）に限られて存在し，18.92 Cl‰ (34.181‰) を示す。すなわち沿岸から NW に沖へ辿れば，高 (18.90 Cl‰)・低 (18.82 Cl‰)・高 (18.86 Cl.‰)・低 (18.84 Cl‰)・高 (18.88 Cl‰) の塩素量分布となり，最北部の st. 41 が依然として，冷水域中での最高鹹値を示す。換言すれば，300m. 層までは，大体18.86 Cl‰(34.072‰) に一定していた塩素量が，400m.層に至つて少しくようすが変り，大和堆を含む中央部の帯状域を除いて，その両側が低鹹化したことを示すものであり，深層水の生成・流動に暖流の影響を受けない，深層水自身のみによる動きが見られるのであるが，これについては後に触れる。

600m. 層：純然たる底層水で占められており，水平的の水温・塩素量などの較差は小数以下となる。すなわち，各種海況要素が地域的にほぼ一定の値を示すようになること，及び対流域内の場合とは逆に，日本沿岸部から補償流的に沖合に向かう流れが顕著になる。以上の2点は最も著しい特徴である。後者の場合は，等量線の分布からも知られるとおり，沖合水の本土へ向かう動きは非常に弱くなる。

水温 (fig. 17) は，0.1°～0.4°C. 台の範囲にあるが，沿岸高・沖合低の分布である。最高温部と最低温部との差は 0.3°C. にすぎない。

塩素量分布 (fig. 18) においてもやはり，日本側から沖合に向かう補償流の存在が顕著に見られる。塩素量範囲は 18.78～18.9‰で，較差はかなり大きい。そして最低鹹部は入道埼沖と能登～佐渡海域に，最高鹹部は佐渡北方の本州沿岸寄りにある。

1,000m. 層：水温 (fig. 19) 範囲は0.09°～0.15°C. でその差僅かに 0.06°C. である。水温分布で面白いことは，佐渡～入道埼から NW 方向にずつと沖合までは，>0.1°C. の高温部となり，周囲は低温部となつていること，及び N41° 以北の沿海州寄りに最高温域 (>0.15°C.) がみられることである。

塩素量 (fig. 20) は，18.82～18.9‰の範囲にあるが，一般に沿岸低・沖合高の分布を示す。等量線の分布も非常に単調となる。

2. 水温・塩素量の垂直分布

1) 禄剛埼NW線 (st. 28→39 ; figs. 21・22)

前にも触れたように，日本海では第一近似として parallel solenoid の理論が適用されるため，等量線の鉛直方向の傾きから，海流の方向及び強さがある程度定量的に推定される。

禄剛埼 NW 線の垂直断面については，等量線の傾きから2つの流れが推定される。すなわち，能登半島にごく接近した，25m. 以浅の isotherms と isohalines の分布で，これは対馬暖流の第1躍層以浅を被う東海系の低鹹水であり，日射によつて高温を呈している。その直下にst. 31から本土に向かつて急傾斜をなす isotherms があるが，これが対馬暖流の主流たる第2分枝であり，Cl も>19.0‰(34.325S‰) 域となつて，その中核は75 m.層にある。能登附近は陸棚が発達しているため，これに遮られて第1分枝は，この第2分枝と合体していると考えるべきであろう。これを越えた沖合の，isothermsの傾斜の緩やかな部分 (st. 33を北限とする) が暖流第3分枝であり，その中核は，st. 32においてやはり >19.0‰を示す。しかし，第2分枝に比べてその厚さが½以下 (35m.) に減つている。st. 34 の大和堆の地形性湧昇域を越えると，さらに高温な高鹹域が見られる

が，その影響は 150m. 層にまで及んでいる。そしてこの部位は，やはり 25m. 層で，19.0‰台の中核をなしている。これは，以西の観測はないが，第3分枝から大和堆西方において，分派して来たものであることは間違いない。

以上対馬暖流中層水は，＞18.9‰ (34.145S‰) 域を以て示される。第3分枝の直下と大和堆以北 1,200m. 層にまで及ぶ 18.84‰ (34.036S‰) 台の最低鹹域は，Liman 中層水の南下潜流域であり，前者は入道埼沖冷水域（低鹹）に連なるものである (fig. 30)。

水温断面から判るように，暖流は沖合ほど表面に浮き上がつてくるが，暖流第3分枝の外側に形成される，表層附近の Liman Front は，st. 36 と 38 との中間 (N40°30′) の isotherms 密集部に位する。このように，暖流の影響がこの附近にまで及んでいることは，O_2断面 (fig. 49) においてより一層明瞭である。

ところで，st. 34 と 35 との中間から以北，第1躍層以深において 1,200m. 深にまでも及ぶ，＜18.85‰(34.054S‰) の広大な低鹹域があり，500m. 以深においては本土に向かつて潜流の形をとつている。この塩分極少層はいわゆる深層水であり，対馬暖流と日本海固有底層水との中間に介在するものである。すなわち 800m. 層の 0.08°C. を中核とする＜0.2°C. 層である。大和堆の南側には，水温は同様に 0.08°C. 台でありながら，Clが＞18.9‰(34.145S‰) という高鹹域が，同様に 600m. 以深にある。すなわち日本海固有底層水であり，これら両水塊の間は5.1 cc./l. 台の酸素極少層によつて分離されている。一方深層水のこのような高鹹値はこの断面にのみ存在する。

以上の事から，Liman Front をなす大和堆〜春風堆附近では，北方からの低温・低鹹・高酸素の Liman 海域で生成された水は，大陸を離れるに従つて，特に Limna Front から，暖流下に潜流し，深度を増しつつ本土に接近する。一方大和堆南縁において，反時計廻りに N〜NE 方向に転向し，その南側に固有底層水の湧昇をひき起しつつ，日本海大循環の一環を形成していると考えられる。

2) 佐渡沢埼NW線 (st. 27→20→41 : figs. 23・24)；この線は能登の陸棚を越した海盆を走るため，暖流の厚みは，1) の断面よりもさらに深部に及び，10°C. 線の深さは前者の2倍 (200m.) となつており，かつ温度傾度も大きい。第1躍層は 1) の場合より 5m. 程度浅くなり，沿岸・沖合を通じて 20m. 深となつている。第1躍層以浅の，大体 10m. 深迄は東海系水の影響を受けて，18.6〜18.7 Cl‰(33.603〜33.784S‰) の最低鹹域となつている。しかしここでは，能登北方で合流していた第1分枝・第2分枝が，再び明瞭に分離して北上するようになる。すなわち，ごく本土寄りの温度傾度の緩やかな 50m. 深までは第1分枝であり，st.24 以南における，isotherms の傾斜の大きい，400m. 附近にまでも及んでいるのが第2分枝，すなわち対馬暖流の本流である。第3分枝は，st.24〜23 の間に，ごく表層に浮き上がつて見られるが，Liman 表層水との混合が著しく，Cl では暖流の痕跡すらなくなつており，僅かに水温・酸素量・PH などによつて確認される程度である。大和堆北部を東流する第3分枝の分派も，st. 21〜20 の間にごく微弱に存在し，表面下数 m. の厚さを持つにすぎない。この分派はこの附近で，N 方向と E 方向の2方向に分流し，前者は st. 42，後者は st. 18 の方へ流れて行く。

第2分枝は，15°C. を中心 (10°〜20°C.) とした＞19.00‰(34.325S‰) 域を以て示され，その深さは本土寄りで 50〜150m. 深にあつて能登地先と変りない。しかし NE 流から N 流となりつつ幅を沖合に拡げるため，暖流中層水も沖合へ拡がつている。

暖流中層水と Liman 系水とのなす Liman Front はst. 23 にあり，1) の場合に比べて僅かに北上しているにすぎない。Liman Front 以北では 300m. 深に 0.5°C. 線があるが，その中でも大和堆以北のものが最も低温 (0.05°C.) であり，1) の場合の最低温域と同じ水塊である。大和堆以南に見られた＜0.1°C. 域は，この断面では 600〜800m.，1,300〜1,800m.，1,000〜1,300m に3分されている。

一方塩素量で興味のあることは，暖流中層水の高鹹であることはもちろんの事として，次の2点である。

a)：Liman 中層水が，1) の場合に比べて最高1‰も高鹹となつて，すなわち ＞18.87‰ (34.090S‰) を中核とする18.86‰の高鹹域となつて100〜500m. の間に存在すること。

b)：大和堆を中心とする st.24→20の間は，表層から200m. 以上の深層に至るまで，18.86‰(34.072S‰) の比較的高鹹域であり，これを挟んで南と北，すなわち大陸寄りと本土寄りに，18.85‰ (34.054S‰)

の塩分極少層のあること。

以上の内，a)の高鹹域は，沿海州方面からの，Liman 系水ではあるが，N41°40′ という同緯度でありながら，緑剛埼断面に見られぬ高鹹であるということは，st. 38～40方面とは違つた水系であることを予想せしめる。換言すれば，同じ Liman 系水ではあるが，st. 38～40 の低鹹・低温の水は沿海州よりも，むしろ北鮮～Vladivostok 方面に起源を有するものと考えるべきである。そして st. 41 以東，N41°30′ 以北の海域は，僅かながらも前の水塊より高温・高鹹である。ということは，前者の水塊は，秋から初冬にかけての大陸気温の低下による海水の冷却，それに伴う南下 Liman 寒流の増勢，その先端部における海水の過冷却が，大陸の沿岸水を混合しつつ Vladivostok 方面で Liman 反流として，日本海中央部に現われたもの，これが同じ寒流域に属しながらも，低温・低鹹な NW 方向からの冷水として本土に指向するものと思われる。

しかし，季節も進み冬ともなれば，大陸沿海は結氷が始まり，それと共に海水中の塩類は析出されて，Liman 系水の高鹹化が進行する。水温は結氷のため，0°C. 以上に一定に保持される。この水が Liman 寒流の一分派として，直接日本海中央部に張り出して来る。すなわち，大陸沿岸水の影響を受けることなく，結氷域からまつすぐに南下する。これが，st. 41 以東冷水域の中の高温・高鹹な分派である。

そして，これら両冷水域は，175m. 以浅では E134°30′ 線と E136° 線に沿う2枝にわかれて本土を指向するが，200m. 以深では合一し，E136°～137° に沿う一本となつて，能登・佐渡方面に向かうこと，前項"水平分布"で述べたとおりである。しかし一本化した後もやはり水温・塩素量・酸素量などに，おのおのの僅かながらその特徴を保持している。

上記 b) における，中央部の 18.86‰ (34.072S‰) 域は，能登断面のそれの続きであり，弱い南下流である。これより北部の低鹹域は，能登断面に見られた，＜18.85‰ (34.054S‰) の極少域の北方域であり，弱い北上流である。北南の，すなわち，暖流域下の同じ最低鹹域は北上流であり，底層水の湧昇域である。そして，大体 400m. 以深において，O_2 5.1 cc./L 台の酸素極少層によつて，暖流水・深層水とはつきり区別される。

3) 新潟NW線 (st. 14→18→43→39 ;figs. 25・26) : この断面は，新潟 NW 線と，N41°40′ 線とを一緒にしたものであり，st. 43 を境にして 135° の屈曲をなしていることに注意されたい。第1躍層は20m. 層にあり，表層水は ＞20°C. 域となつている。st.39にも＞20°C. 域が見られるが，これは低鹹・高酸素の Liman 表層水であり，夏の強い日射により昇温したものである。第1躍層下100m. 深位までの，温度傾斜の緩い所は，暖流第1分枝であり，st. 15～16 を中心とする急傾斜の部は暖流第2分枝で，2,000m. 深位までは ＞10°C. となつている。第3分枝は，st. 18 附近に20°C.，18.9‰ (34.145S‰) 台，O_2量 ＜5cc./L となつて第1躍層以浅にあり，非常に薄いものとなつている。すなわち，st. 18 が Liman Front の位置する所であり，この点から第1躍層下の isotherms は本土に向かつて急降下する。Liman Front 以南においては 600m. 以深が，以北では 400m. 以深が，＜0.2°C. となるが，最低温域は 600～1,200m. の 0.05～0.07°C. 域である。この水温極小層は，深層水と固有底層水との中間にある O_2 minimum 層の水であり，本土から大陸へ向かう補流性の水である。

暖流系水はやはり，＞18.9‰(34.145‰) 域を以て示されるが，その中核水も依然として ＞19.0‰(34.325S‰) 水であり，それぞれの深さも既述の断面 1)・2)と変らない。

第1躍層下の沿岸・沖合を通じる Cl minimum 層は，暖流域下の＜18.83‰ (34.018‰) 域であり，O_2 minimum 層に当る。そしてこれとは対蹠的に寒流下に，先に緑剛埼沿岸寄りに見られたのと同じ 18.9‰台という高鹹水が，800m. 以深にある。すなわち固有底層水である。今直ちにこの固有底層水の起源を詳かにすることはできないが，前にも触れた沖合冷水の2分派の内の，沿海州に由来するものであろう。北鮮ないしは Vladivostok 方面に由来するのではあるまい。そしてこれが日本海海盆の海底に沿つて，本土に南下・接岸して来る。それが本土の陸棚に達すると，ごく微弱な速度ではあるが，とにかく湧昇流の形をとつて，表層の方へ上向きの爬行となる。すなわち 1) に述べた，緑剛埼寄りに ＞18.9‰ 域が存在する理由である。しかしこのように，＞18.9‰というような高鹹域が本土寄りの暖流域下に存在するのは，緑剛埼断面にのみ見られる現象である。この説明をどうするか。それは，

a) : 従来概念化されている日本海固有底層水も，海底からその上縁まで水温は一定であつても，Cl その

他化学成分の異つた何層かの安定な水によつて層状に形成されている。

b)：この何層かの水は，海水の特性として周囲から変性を受けることが少なく，一団となつて，すなわち一つの固有底層水としての特性を持続しながら，本土陸棚に到達する。この場合海底に近い層程高塩分であろうことは，底層水が這い上る日本海の bank で，海底（bank）に近ずく程高塩分になる事実から考えられる。

c)：固有底層水を構成する各層が，その特性を失わずに持続するのは，単に日本海海盆中の比較的平坦な日本海中央部においてのみならず，本土陸棚斜面上を這い上る時もまた同然である。

以上3つの前提が正しいとすれば，禄剛埼 NW 線においても，本土沿岸に近ずく程高鹹となり，最沿岸部で，18.9‰台の最高鹹域となることは当然であろう。この元が，st. 41 以南に見られる >18.9‰の高鹹水である。塩素量の垂直分布を細かにみて行くと，500m. 深と1,000m.深とに，本土側から沖合へ向かう補流が見られるが，この2点は O_2 minimum層であり，また O_2 飽和度の minimum 層である(figs. 53・54)これに挟まれる 500〜1,000m. の層は深層水である。

O_2 分布から固有底層水は 1,400m. 以深に見られるが，塩素量からは禄剛埼沖におけるようなはつきりした差異はなく，深層水と同じ 18.83‰台を示している。このように特性を失い易い底層水が，何故に禄剛埼だけに高鹹性を示し，その他の断面では 2,000m. 深に至るまで低鹹であろうか。それは各断面線の海深を考えることが必要である。すなわち，禄剛埼沖の海底は，陸棚が割合沖合までよく発達しているのに対し，その他の断面では，急深の地形となつている。しかも海底近くまで観測されたのは，以上述べた海深の関係で禄剛地先のみであり，他の断面では海底から 1,000m. も上の方に止まつている。従つて前記の底層水の爬行状態から見て，同じ底層水の観測をしたと言つても，禄剛埼地先では底層水中の最下層（高鹹層）にまで及んでいるにもかかわらず，他の断面では底層水の上部（低鹹層）にしか及んでいないことに原因があろう。すなわち禄剛埼では底層水の浮上が大きく，他では海深が大きかつたことが原因である。また既述のとおり，同じ底層水でも，大陸沿岸での生成時期を異にしており，禄剛埼を除いては，8月に本州沿岸に到達するものは，結氷直前或いは融氷直後の低鹹・低温の水であろうと考えられることも一つの原因であろう。このような考え方は，底層水のみならず，その上にある深層水についても当てはまるのではなかろうか。すなわち同じ深層水でも，大陸沿岸で生成される時期の相違によつて，沖合よりも本土寄りの方が低鹹になる

4）加茂NW線（st. 13→8：figs. 27•28）：第1躍層は10〜25m. 深にあり，10m. 以浅は東海系水に本土沿岸水の混合した，>25°C.，<18.8Cl‰の高温・低鹹の水である。この断面は飛島陸棚を横断するため，地形性湧昇が顕著である。すなわち，本土陸棚の西方では等温線が上向き，10°C. 線を見ても西側（沖側）では 180m. 深にあるが，東側（本土側）では 150m. となつている。こうした湧昇傾向は 0m. 層にまで及んでいる。表層流の厚みは，この断面に至つてそれまでの ½ 以下の10m. となるが，Cl は湧昇暖流の影響を受けて，逆に高くなつている。

暖流第1分枝はやはり 100m. 深にまで及んでいるが，第2分枝は飛島の西側（沖側）を通つている。第3分枝はこの断面よりさらに沖合にあるため現われていない。第2分枝の中核水は，150m. 深まで 19.0‰台で，依然変りはないが，18.9‰までを暖流域と見て，各断面における最大深度を求めると，次のようにこの断面が一番深い。

断　　面	St. No.	18.90‰線の下縁の深さ
禄剛埼NW線	29	200m.
沢　埼NW線	27	〃
新　潟NW線	15	250
加　茂NW線	10	>420
艫作埼 W 線	1	250

暖流中層水の中でも，その中核は 19.14‰を中心とする，非常に高鹹な水が可なり広い範囲を占めている。これは水平分布の項（28頁）で述べたように，高鹹水塊として暖流中を独立して北上して来たものである。

5）艫作埼W線（st. 1→5→18→20→38；figs. 29•30）：第1躍層は暖流域内では 15m. 層を中心として存在するが，寒流域内では 10m. 層にある。Liman Front は st. 20 にある第1分枝は，加茂地先と同様に非常に岸近くに圧迫され，艫作埼から30浬の幅を持つているが，その内艫作埼寄り

の15浬は南下流（0.1 kt.）となつているので，北上流は艫作埼沖15浬から30浬までの15浬の幅を持つにすぎない。艫作埼寄りの南下流は，第1分枝の南下流で，権現埼方面で反転して沿岸沿いに南下したものであり，水温・Cl・O_2量などには全く差がなく，この附近によく発達する時計廻り環流である。第2分枝は，st. 2 を中心とする isotherms の急傾斜部に当り，isohalines と同様に，各断面中その側斜が最も急であり，かつ本土側に圧迫されている。

今10°C. 線を対馬暖流中層水の下縁とすれば，この断面では st. 1 で一番深くて 130m. にすぎず，1)〜4)の各断面の200m. 深に比べて 70m. も浅くなつている。このように，第1分枝・第2分枝の沿岸への圧縮・下限の浮上ということが，艫作埼断面における大きな特徴である。結果として最大流速を示す（北上流 >0.5 kt）結果となり，表層の実測では4〜5 kt. の所さえあつた。また一面，この沿岸への圧縮は暖流の津軽海峡への逸出の強勢をの一端を示している。

第3分枝は，st. 18 の第1躍層以浅にあつて，>25°C.・18.9‰・O_2 > 5 cc./L の海域を以て示される Liman Front は st. 20 にある。

さらに，この断面の特徴としては，isotherms において，暖流第2分枝の下では 1,000〜1,800m. に，以沖では 600〜1,000m. に 0.05°〜0.09°C. の水温 minimum 層が連続して，帯状に存在すること，及び st. 4〜5 を中心として，表面から 2,000m. 以深にまで及ぶ 18.79‰（33.946 S‰）台域が，垂直に柱状に存在することである。

他の断面でももちろん< 0.1°C. 域は出現していたが，このように連続はしていなかつた。この水温 minimum 層は O_2 minimnm 層であり，深層水と固有底層水との中間に介在する水であり，底層水に由来する本土側から沖合への補流に外ならない。すなわち沖へ行くに従つて浮上し，本土沿岸部と極前線以北の冷水域とでは，後者の方が 800m. も浮上する。

st. 4〜5を中心とする表面から 2,000m. 深以深に及ぶ低鹹の柱状水塊も，上層から 150m.・200m.→300m.・1,600m. 以深の3層に区別できる。これら3層は，すべて18.79‰台であるが，0〜150m. 層は18.6‰（33.603 S‰）を中核としており，低鹹・比較的低温・O_2量は 8 cc./L 台を中核とする 7 cc./L 台の高酸素域であつて，明らかに Liman 寒流域の第1躍層直下の水であり，弱い南流を示す。200〜1,300m. の低鹹柱状水塊は，佐渡北部の海谷を伝わつて能登〜大和堆の中間に向かつて南西流する深層水である。すなわち，400m. 以深の南流分はごく弱く0.04 kt 程度である。1,300m.以深は底層水であり，比較的高温・高酸素の水塊である。この深層低鹹水が南西流するほど高鹹となるのは，既述のとおり（400m. Cl水平図 fig. 16）南部と北部の両水塊の大陸沿岸における生成時期の相違及び南西するほど海底地形が高まつて，海深が浅くなることに関係があるのだろう。

800m. 以浅，Liman Front 以沖に <18.85‰（34.045 S‰）の低鹹域が本土に向かい沈降している。これは Liman 寒流中層水で，0.5°〜0.1°C. の水温値を持ち，O_2も比較的多く 6〜7 cc./L である。そしてこれの本土寄りの先端部，すなわち st. 19〜20 を中心とする弱い南流成分（< 0.1 kt.）を示す。

Ⅲ 溶在酸素量（附・酸素飽和度）の分布

1. 溶在酸素量の水平分布

0m.層を除き各層についてO_2の分析（L. W. Winkler 法）を行なつたが，各水系については水温・Cl^-の項で詳述したので，O_2 分布については比較的簡単に触れたい。また，飽和度の分布は O_2 量の分布と同じ傾向を持つているので，O_2 量分布を述べるに当つて援用する程度に止める。

水温差・塩分差，特に後者の小さなことは日本海の一大特徴であり，T—Cl diagram で微細な水塊分析の行ない難いことは層に痛感されるところである。唯幸いな事には，太平洋などにおけると同様に，O_2分布が最もよく各水塊の特性を表わしてくれる。日本海の海況研究には，O_2分布の研究は欠くべからざる要素である。こうした利点は，暖流中層水下の，300m. 以深における水温・塩分の水平分布図とO_2のそれとを比較すれば，一目瞭然であろう。

さてO_2の水平分布は，各層共水温・塩分のそれと変つた所はない。今第1躍層以浅の表層水の代表として10m.層を，暖流中層水として 50m. 層を，深層水として 400m. 層を，固有底層水として 1,000m. 層をとつてみる。

1） 10m.層 (figs. 31・32)：暖流系水は 4.5〜5.5 cc./L に一定しており，Liman Front は 5〜6 cc./L の等量線密集部を以て示される。Liman 系表層水は ＞ 6cc./L を以て示される。大観すれば沖合ほど高酸素域となるが，同じ暖流域でも佐渡以北において高酸素であるのには，第1躍層直下を南流する本土沿岸沿いの冷水域の影響を受けているためである。水温や塩分の分布では 25m. 以深にしか見られなかつた艫作埼西沖の E136° 線に沿う沖合南下冷水域が，O_2分布から 10m. 層においても存在することが明らかに看取される。入道埼以北のごく沿岸沿いにある 4.8 cc./L の O_2 minimum 域は，沖合第3分枝の津軽海峡西方における時計廻り環流に因る南下流と津軽海峡に由来する低酸素表層水との混合したものである。

O_2量の少ない暖流中の st. 29・st. 34 に，それぞれ 5.65 cc./L・6.55 cc./L という比較的高酸素域があるが，これらは地形性湧升流に因るものであり，寒流系中の st.18 (6.37 cc./L)及びst.37 (7.52 cc./L) は，第1躍層直下の高酸素の Liman 系水の上方へのふくらみに因る。

2） 50m.層 (figs. 35・36)：大観してやはり沖合ほど高酸素域となる。Liman Front 及び暖流域は，10 m. 層と同様にそれぞれ 6〜7 cc./L の等量線の密集帯，5 cc./L 台域を以て示されるが，この層は第1躍層の下にあるため Liman 系水の影響を受けて，4 cc./L 台という低酸素域はほとんど全く消滅する。第3分枝も Liman 系水の影響を受けることが大きくなり，10m. 層よりも高酸素となる。また大和堆西方において分派された大和堆北方の分派も 1 cc./L 増えて，6.8 cc./L となる。全観測点を通じる最高値は st. 42 の 7.83 cc./L, st.21の7.92 cc./L である。すなわち第1躍層直下で生成された Liman 水の中核である。

これらの図で著しく目につくことは，入道埼沖冷水域・その西側に位置する暖流の北上分派・さらにその西側にある沖合冷水域の受けている影響が，水温や塩分で表わされる以上に大きいことである。

3） 400m.層 (figs. 43・44) 10〜300m. の各層と同様，E139°線に沿う冷水域（入道埼沖冷水域）・E138°線に沿うもの・大和堆上のもの，以上3本の沖合冷水域が顕著に表われている。この内最も本土寄りの入道埼沖冷水域は 600m. 以深では全く消失し，他の2本は 400m. 以深において共に能登北岸に指向する。

＞6 cc./L 域は純粋な寒流域であるが，これはまた塩分極少域でもある。

4） 1,000m.層 (figs. 47・48)：600m.層まではつきりと出ていた水塊的な酸素量分布も，1,000m. 層ともなると，水温・塩素量の場合と同様に，著しく単調になる。特にその飽和度の単調化には著しいものがある。酸素量は st.38 の 6.5 cc./L の最高域並びに佐渡 NNW に多く (5.5 cc./L)，他は一般に 5.1〜5.4 cc./L である。

以上 O_2 水平分布を通観して目につくことは，Liman Front 以北は Liman 系の寒流域であるため，以南の暖流域より一様に O_2 量多く，飽和度も高い。しかし高い中にも大体，E135° 以西は以東よりも低い。このことは水温・塩分の水平分布の項で触れたとおり，表面から 2,000m.深（今回観測の最大実深）に至るまでE135° 以西の方が，以東よりも高温・高鹹であることと符合する特性である。このことも，E134° 線と E136° 線とに沿う2大南下冷水域の生成機構が必ずしも同一ではないことを示すものであろう。

2． 溶在酸素量の垂直分布

1） 禄剛埼NW線 (st. 28→39: figs. 49・50)：O_2量は 5.10〜8.61 cc./L の間に変異するが，水平的には水温・塩分の分布とは逆に南低北高，垂直的には深いほど低くなる。暖流の第1・第2分枝は 5 cc./L. 前後である。st.32〜33・st.35〜36 に ＜5 cc./L の低 O_2 域があるが，これらはそれぞれ暖流第3分枝及び大和堆西方でその北方へ分派した第3分枝の派流である。暖流域では飽和度は ＜100%，寒流域では ＞100%（最高はst. 38 表層の140%)，また垂直的には大体 50m. 以浅が ＞100%，以深は不飽和で，深層ほど不飽和度が大きくなり，最低は暖流域内 500m. 以深の64〜65%である。＞6cc. 域は南北を通じて大体 100m. 以浅にある。

この断面ですぐ目につくことは，200m. 以浅では高酸素（高飽和度）の寒流系水が，st.31・36・39 及び 1,000m. 層の4か所から本土へ向かつて南下潜流していること，これらの間には逆に深層から斜め上方に北上する低 O_2 水が4本見られること，これである。前の高酸素水について述べると，st. 31のものは暖流第2分枝と第3分枝との間から第2分枝の下に潜り込む上層水，いわゆる intermediate water である。st. 36 のもの

は，Liman Front から暖流域下に下降するものであり，Liman 寒流の第1躍層直下の上層水であり，同寒流の intermediate water である。st. 39 のものは Liman 中層水そのものと考えられる。すなわち Svevdrup も言つているとおり，結氷域の沿岸に接する所では，対流は海底にまで及び，いわゆる底層水となるが，結氷域の他の部分では対流は海底までは達せず，ある深さにおいて止まるであろう。かかる海水はその密度に応じて，周辺に拡散移動する。いわゆる深層水であるが，st. 39 の下降流はかかる深層水を示すものである。

st. 39 の1,000m. 深にも沈降流が見られるが，この沈降源は st.39 よりさらに大陸寄りにあるはずである。それはソ・鮮国境方面で，Liman 寒流水の南西端附近に形成される Liman Front と思われる。

次に前記の上昇流について触れる。本土沿岸沿いに SW から NE に流れる対馬暖流は，精々 200m. 前後の厚みを持つにすぎず，しかもこれが日本海における，日本海以外の海から供給される唯一の水である。それより以深の水は，日本海が海盆であるという性質から，すべて日本海自身の内部で生成され，涵養されたものでなければならない。それは，表層においては Liman Front 以北の寒流域から供給され，深層水・底層水また北方大陸方面から供給されるなど，主な水塊（暖流以外の）は全部大陸寄りから供給される。従つて日本海海盆が安定を保つためには，何らかの形で本土側からの補充流がなければならない。今この断面を見ると，中央部に 200m. 前後の厚みを持つ O_2 minimum 層（5.1 cc./L台）が，全域にわたつて帯状に連なつている。この層は又，水温 minimum 層でもあり，O_2 飽和度の minimum 層でもあり，以浅の深層水と以深の底層水との境界面をなす。

今ここにとつた4本の上昇流は，すべてこの O_2 minimum 層に由来することは明らかである。一方この O_2 minimum 層は底層水と同様に，水平的には移動の甚だ小さなもので，海盆の底部に淀んだような状態にあると考えられる。すなわち，これら上向きの低 O_2 水は補流と見なければならない。ただし4本の内，最も本土寄りの1派は地形性の湧昇流であつて，他の3本とは性質を異にする。

大和堆附近には，地形性湧昇流の影響が多分に見られるが，この湧昇流については，水温・Cl・営養塩類などと一括して後述する（第3章及び“1955年夏季北部日本海に於ける微量栄養成分の分布について”参照）。

2) 佐渡沢埼NW線 (st.27→20→41 : figs. 51•52) : 1) の禄剛埼 NW 線の場合と同様に，O_2 minimum 層からの補償流が4本見られ（st. 26 • 24 • 22 • 41—この内 st. 26 のものは O_2 分布では明瞭でないが，飽和度分布には明瞭に現われる），これらの間に挟まれて3本の高酸素の沈降流がが見られる。これら沈降流は，すべて st. 42 を中心とする沖合冷水に由来するものであるが，O_2 の水平分布から次の事が言える。

a) st. 24 から st. 25 の 200m. 深へと沈降する高 O_2 水塊（>6 cc./L）(1) は，艫作埼沖冷水塊が混合したもの

b) st. 23 〜24 へ沈降する >6 cc./L 水塊 (2) は，st. 41 から SE に南下したもの。st. 21〜20 の沈降流 (3) は，st. 41 から SSW に南下したものである。

そしてこれら3本の沈降流を比較すると，北方に位置するものほど高酸素層・高飽和度層の下限が深層にまで及ぶ。すなわち高酸素水塊の厚みが増す。このことは，暖流の卓越する禄剛埼NW線にも，新潟 NW 線，加茂 NW 線にも見られるが，この線において最も顕著である。今その下縁の深さを，以上3沈降流について比較すれば次表となる

沈降流	6 cc. 水塊下縁の深さ	飽和度70%線の深さ
(1)	200m.	250m.
(2)	300m.	350m.
(3)	500m.	650m.

暖流系水は < 6 cc./L 域を以て，寒流系水は >6 cc./L 域を以て示されることは前と同様であるが，禄剛埼 NW 線から僅か 30浬北へ離れただけのこの断面が，禄剛埼線とは次のように著しく異る。

a) 前の断面のような 8 cc./L 台という高酸素域はなく，st. 21 の 50m. における 7.92 cc./L を以て最大値とする —— これは E135° 線に沿つて南下する，北方冷水域の南端部に当る所である。

b) 沈降流・補流共に3本であり，観測点の位置の関係上（最沿岸寄りの st. 27 も陸棚を離れた沖合にある），本土陸棚沿いの地形性湧昇流は図上には出てこない。

c) 一般に寒流系水の厚みが増している。——これは >6 cc./L 域をとつて見ても判るが，Liman Front 以南においてはその下縁は大体 200m. 深，以北では最高 400m. 以上となつて，共に禄剛埼線の2倍である。ことに Liman Front を境にして，以北では断層的に厚みを増す。

d) O_2 minimum層(5.1 cc./L台）は Front 以南，すなわち大和堆以南のみにあつて，以北寒流域下にはない。そして大和堆以南においては，この O_2 minimum 層の下に 5.2〜5.3 cc./L 台の高酸素層がある。

また O_2 飽和度の分布は，O_2 量のそれと全く同一であるが，次の点において禄剛埼 NW 線と異なる。

a) 最高値は両線共に Liman Front 以北の沖合冷水域中にあり，共に約 130%であるが，Front 以北でもまた共に表層（O_2 試料の採水は数 st. において 3m・5m・7m 深などで行なつたが，一般に 10m. 層を以て最浅層としたので，本文で述べるところは，10m. 層を以て表層と表現する）まで過飽和であるが，以南では大体 15m. 層に至つて初めて 100%となる。この深さは，禄剛埼より数 m.浅くなつている。このことは暖流層の厚みの減つたことを意味するのであるが，特に禄剛埼 NW 線では暖流第3分枝の中心域である，st. 35〜36 では 100%線は 30m. 深に見られる。

b) 禄剛埼 NW 線では，100%水塊の下縁が <25m. 深となつている能登北岸の40 浬までの，ごく沿岸部及び大和堆上の湧昇域を除いては，沖合に至るまで大体 60〜70m. 層に一定している。しかるに沢埼NW 線でこの深さにあるのは，st. 24〜21 の間だけであり，以北・以南共に浅くなつている。すなわち以北では 50深m.，以南では 30〜40m. 深に位置する。

c) st. 41 の 200m. 以浅では，水深による飽和度の変化が漸変的でなく無秩序であり，同じ沖合冷水域といつても，この附近の水塊の mosaic 的な複雑さが窺われる。これの解明は，冷水塊の生成系統の解明の鍵であろう。

3) 新潟NW線 (st. 14→18→43→34 : figs. 53・54)：この断面は一番沿岸寄りの st. でも距岸 100 浬もあり，沖合暖流域の北縁部に位置している。にもかかわらず，O_2 量は艫作埼沖冷水域の影響を受けて，2,000m. の深層に至るまで多い。すなわち，前記 1)・2)の1,600〜1,800m. 層の max. がそれぞれ 5.29 cc./L ;5.46 cc./L であるのに比べ，この断面では 5.76 cc./L である。一方 >6 cc./L 域もその厚みを増し，その下縁は 600m. (st.16)，800m. (st.18〜43 の中間）と著しく深くなる。逆にこの上縁は，st. 43 以南では 10m. 深前後にあり浅くなつている。これら両高酸素域は，艫作埼沖冷水域に由来しており，これらと交互して，st. 15 及び18 の両所に深層の低酸素水の湧昇（補流）が見られる。最北端線である st.43〜39 の間では，st. 42 附近に> 6 cc. 域があり，その西方（st. 40 附近）に深層からの湧昇がある。

本断面の max. は，st. 43 の 23m. 深における 8.86 cc./L であるが，この値は st. 4（艫作埼西方67浬）の 8.88 cc./L と並んで，今次観測の最高値である。そして各断面中，本断面において 8 cc./L 台水域の占める範囲が最も大きい。すなわち，st. 41 以西の上縁を 15m. 深に，下縁を 35m. 前後の深さに持つ厚さ 20m. のものと，その東方 st. 42〜43 を中心とする 75m. 深に及ぶものとの2つである。この内，前者は Liman Current の，より末端の分枝(ソ・鮮国境方面）に由来し，後者は st. 43 を中心とする，Liman Current のもつと元の方（末端より NE 方向）の分枝に由来するものである（それぞれ 25m. 層・50m. 層の O_2水平分布図—figs.33〜36—参照）しかして後者は既述のとおり，大和堆上方を北上する暖流第3分枝の分派が混合しており，ために前者に比べて高温・高鹹となつている。

<5 cc./L の低酸素域は，st. 18 以南の暖流域に見られるのみである。

本断面の全 st. にわたつて，一般に 50m. 以浅は過飽和となつており，特に st. 43 の両側は，100m. 深まで過飽和である。

飽和度 minimum 層は st. 14〜43 の 1,800m. 以深にあつて<65%，maximum は st. 43 の 20〜25m. における 130%である。

4) 加茂NW線 (st. 13→8 : figs. 55〜56)：本断面は，飛島近くの浅い，しかも海底地形の複雑な海域を通つているが，水温・塩分の場合よりも，より一層次の事が明らかである

a) 狭長な海谷における (st.12)，6 cc. 線の顕著な上昇。これは，飛島と本土との間の狭長な海谷に沿つ

て南下する。鱸作埼沖冷水域（st. 4を中心とする）の南下に因るものである。st. 12の100m.層における6.15 cc.は，本断面の最高値である。飽和度の100%線もこの海谷で一番深い所（170m.深）にある。

b) その西方st. 11（飛島陸棚上）における6 cc.線の著しい下降。これは飛島のすぐ西側を暖流が北上しているからである。

c) st. 11の西方st. 10（飛島陸棚を離れ海深900m.）では，再び6 cc.線が上昇する。これも鱸作埼沖冷水域の南下による。

すなわち本断面では，飛島のすぐ西側の暖流を，その両側から鱸作沖冷水が挟んでいる形になつている，一方st. 10〜8 の 25〜60m.にある，可なり広範囲の高酸素域（>6 cc.）もやはり鱸作埼沖冷水域からの南下流を示すものである。

5) 鱸作埼W線（st.1→5→18→20→38: figs. 57・58）：この線は鱸作埼正西330浬にわたるものであるが，その位置の関係上鱸作埼沖冷水域の影響が，各断面中最も顕著に現われている。6 cc.線はst. 5において最も深く600m.深にあるが，その他では浅くなつている。しかしそれにもかかわらず沖合線であるが故に，400〜500m.深に6 cc.線があり，O_2量の多いことは各断面中随一である。飽和100%線もst.5を中心として最も深く（75m.層），6 cc.線と同じかつこうをしている。st. 18以西では大体50m.深に100%線が横たわる

>8 cc.の特にO_2の多い海域はst. 4〜5・19・37以西の3か所，しかも50m.以浅という表層にあるが，この内st. 4〜5のものが値が最も大きく，8.88 cc.を中心としている。これら3者は，それぞれ鱸作埼沖冷水域・E136°線に沿うLiman系水・ソ鮮国境附近の冷水域を示すものである。そしてst. 5の370m.〜420m.に見られる>7 cc.域も鱸作埼沖冷水である。

対馬暖流域を示す表層の<6cc.域は，各断面中最小であるが，一方st. 1〜2にわたつて270〜410m.層に<6 cc.の低酸素域がある。これは飽和度分布図からも明らかなように，低酸素の深層からの補流であり，st. 3ないしst. 4に向かうものである。

Ⅳ 水色・透明度

全観測点について水色・透明度を測ることを原則としたが，観測時間が日没後の場合は測定できなかつた。従つてfigs. 59・60には欠測点のあることも止むを得ない。こういう不満足にもかかわらず，等値線を画いてみると，やはり他の海況要素と同様の水系を表わしている。

透明度は7〜27m.の間に変異し，水色はForel's scaleの2〜5である。対馬暖流系水は透明度20m.以上，水色2〜2.5で表わされ，Liman Front以北のLiman系水は20m.以下，3〜4で示される。特に対馬暖流の本流たる第2分枝では27m.以上の海域もある。

一般に沖合ほど，また北するほど水色・透明度共に悪く，ごく沿岸部もまた悪い。沿岸部の中でも，佐渡〜加茂間にNWの沖合へ延びる，水色・透明度の悪い水塊があるが，これは後記planktonの項で述べるとおり，24時間沈澱量は沿岸部としては普通量にすぎぬが，*Rhizosolenia styliformis*・*Crseis aricula*などの，小型動・植物の繁栄に因るものである

またst. 17は，目立つて水色・透明度が悪く，それぞれ5・7m.という全測点を通じる最低値を示している。すなわち，*Ceratium Carriense*の大豊産に因る。

Ⅴ 水素イオン濃度

水素イオン濃度の水平的・垂直的の分布は既述の化学成分の場合と同様であるが，水平分布についてはfigs. 61〜69を，垂直分布についてはfigs. 70〜73を参照されたい。ただ日本海においては，下層水の湧昇，上層水の沈降は，水温・塩素量の場合よりも，PHの垂直分布による方が，より大きく強調して表わされる。

Ⅵ 1955年8月の海況と1954年8月の海況との比較（50m.層について）

日本海の対馬暖流域内では最近数年来，次第に高温化しつつあること，流速も南部において衰え，逆に秋田

〜北海道方面で増大しつつあること，また暖流は沖合へ拡がりつつあること等々の一般的趨勢にあることは既に発表のとおりである（下村・宮田，1956)。

しかし，こうした趨勢の中でも，相次ぐ年の間にかなりの海況変化がみられる。ここには1955年８月を前年の８月と比較してみる。但し1954年８月の観測範囲は精々距岸100浬程度で，1955年8月の$\frac{1}{3}$にも及ばないので，1954年８月の観測範囲について，その差をあげる。なおここには，対馬暖流の中核水として，50m.層を以て比較の規準とする。

1）沿岸の 20°C. 等温線の位置

1955年には，隠岐島沖・能登半島沖，佐渡沖を通り，秋田県南部にまで達する。

1654年には，鳥取県西部を北限とし，しかもごく沿岸沿いに走つている（隠岐島の南側というよりむしろ島根半島に近接してみられる）

2）15°C. 線の位置

次のように1955年は，54年よりも沖合に位置する。

	1955年	1954年
経ケ岬沖では	N38°10′	N37°
佐渡NW沖	90浬	45浬
艫作埼W沖	10浬	15浬

3）入道埼沖冷水域

1955年８月はこの冷水域の発達は非常に弱い。今 15°C. 線を以てその外縁とすれば，1955年８月の南端は N 39°50′にあり，入道埼W沖30浬を，NE→SW に走る 15°C. 線が見られる。しかし1954年８月には，入道埼 W12浬において，ほとんど南北の方向に 15°C.線が走つている。

すなわち，1954年８月に比べて，冷水域の南端は50浬の北退，入道埼W沖では約20浬の西退が見られる。

4）佐渡冷水域

1954年８月はあまり発達しなかつたが，1955年８月は非常によく発達し，北方から SE の方向に，能登半島と佐渡島との中間に向かつている。そして 400m. 層では，N38° 線に沿つて，佐渡島へ向かつて東へ延びている（0.5°C.）。

5）若狭沖冷水域

これは“山陰・若狭冷水域”の一部に当るものであるが，1954年は，隠岐島 NNE 130浬附近の中心部（11°C.台）から，SE 方向で隠岐堆に向かう。100m. 層以深では，それが N36°30′ 線に沿つて東方へ（能登へ）張り出していた。1955年は，これが非常に強勢で，E135° 線に沿い，まつ直ぐに経ケ岬へ向かつて南下している。すなわち，流軸は1954年よりも1°だけ東偏したかつこうになつている。そして 75m. 層以深では，この冷水域の南端は完全に経ケ岬に接岸する。

6）隠岐沖冷水域

これは“隠岐NW冷水域”の一部に当るものであるが，1954年はあまりよく発達しなかつた。しかし 1955年には余程はつきりとしており，NE 方向から浜田に強勢に接岸している。その圧迫接岸状況は，浜田から日御碕にまで及んでおり，他の一分枝は隠岐島南部にまで入り込んでいる。

7）以上の内，若狭沖冷水域の東偏及び隠岐沖冷水域の隠岐島西方への強い発達のため，当然の結果として1955年８月の沿岸の暖流に路は違つた様相を呈した。すなわち，1954年及び1931（昭和６年）に見られたような，隠岐島西方を北西流することはなく，隠岐島と島根半島との間を通つて，しかる後，隠岐東方を NEへ流去するような分派を形成しつつ，本土沿いに東流している。

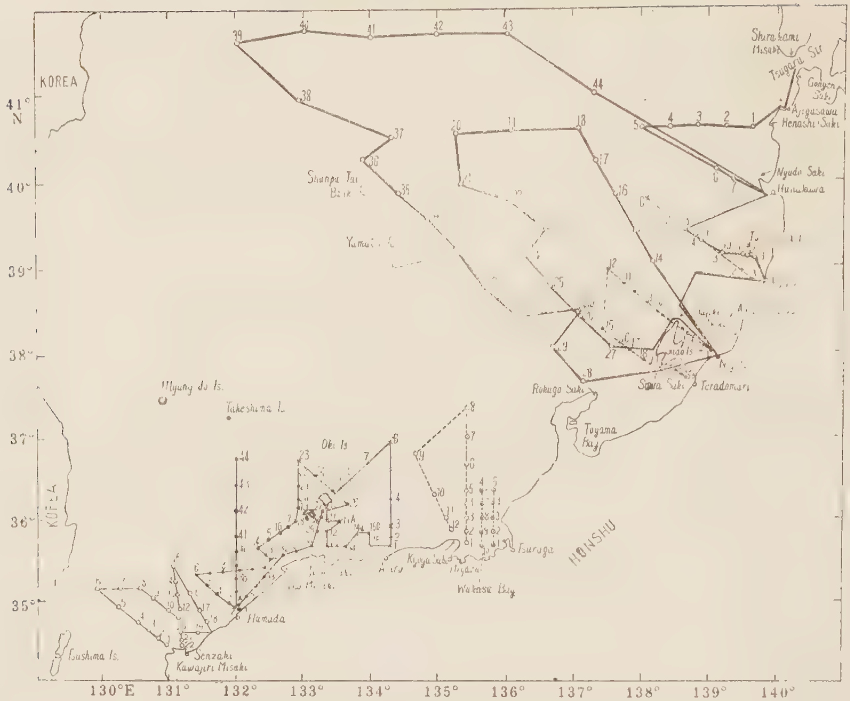
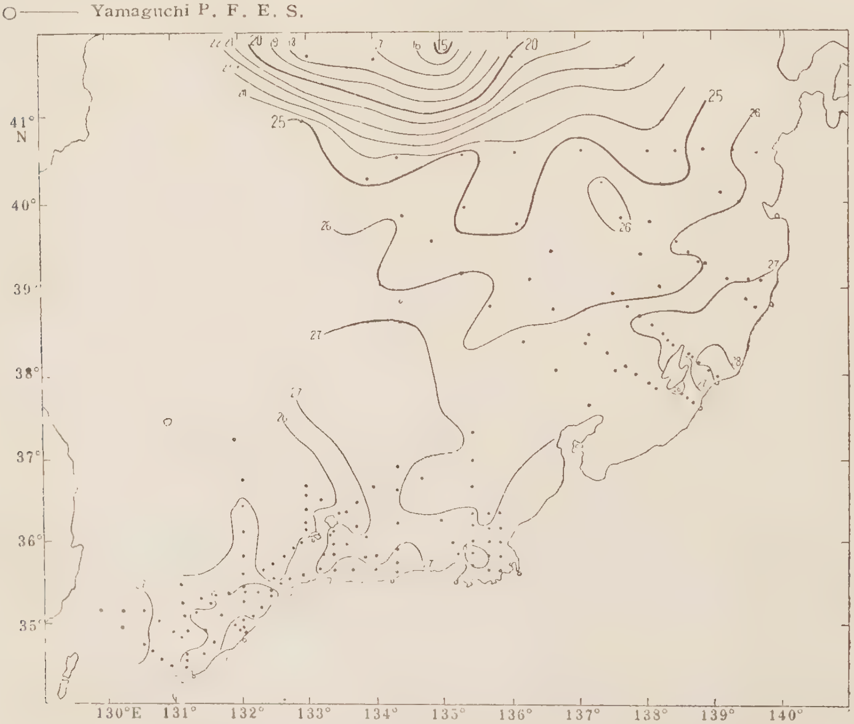


Fig. 1. Location of the obsevation stations.

- ○—— Japan Sea Reg. Fish. Res. Lab. (the Soyo Maru)
- ×------ Yamagata Pref. Fish. Exp. St.
- ●------ Niigata P. F. E. S.
- ◎ Fukui P. F. E. S.
- ○ Kyoto Fu Fish. Exp. St.
- ×—— Tottori P. F. E. S.
- ●—— Shimane P. F. E. S.
- ○—— Yamaguchi P. F. E. S.



ig. 2. Horizontal distribution of temperature (°C.) at 0-metre layer.

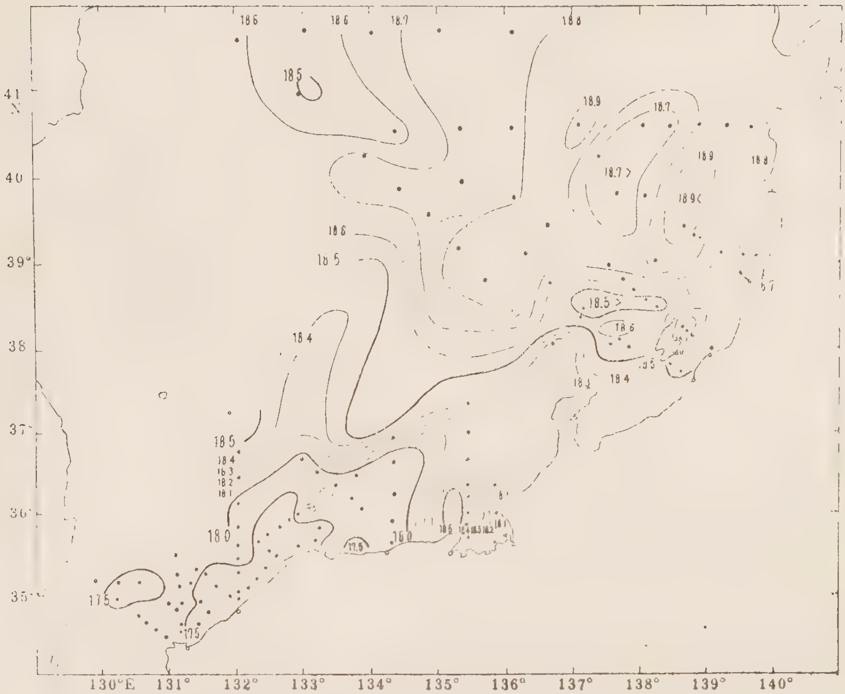


Fig. 3. Horizontal distribution of chlorinity (‰) at 0-metre layer.

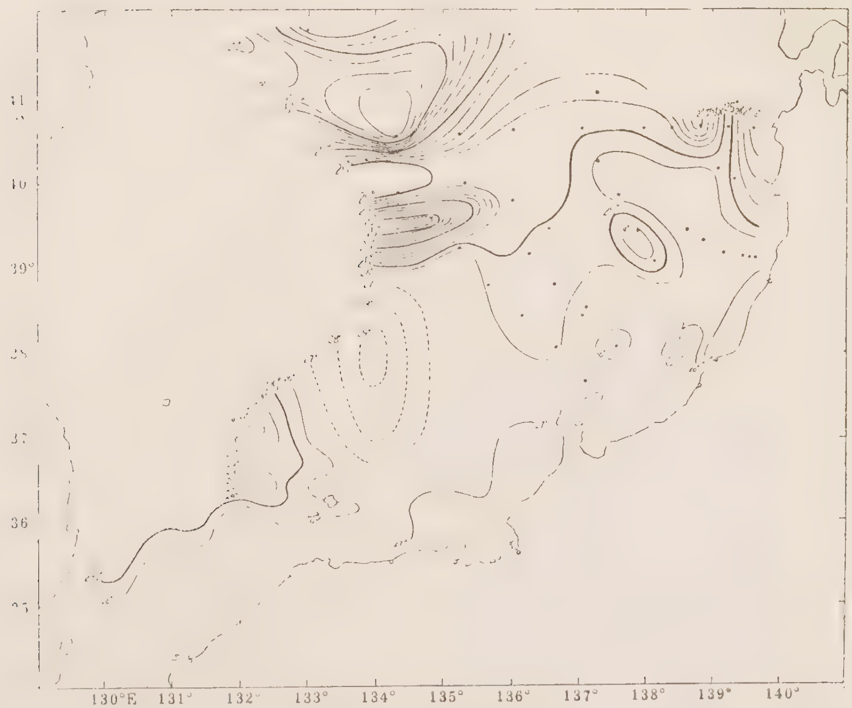


Fig. 4. Horizontal distribution of temperature (°C.) at 10-metre layer.

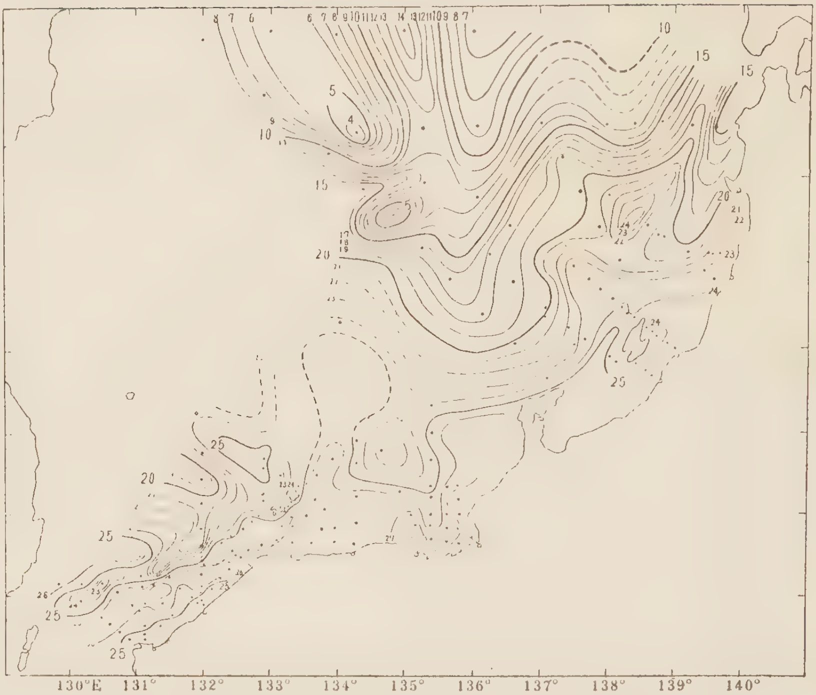


Fig. 5. Horizontal distribution of temperature (°C.) at 25-metre layer.

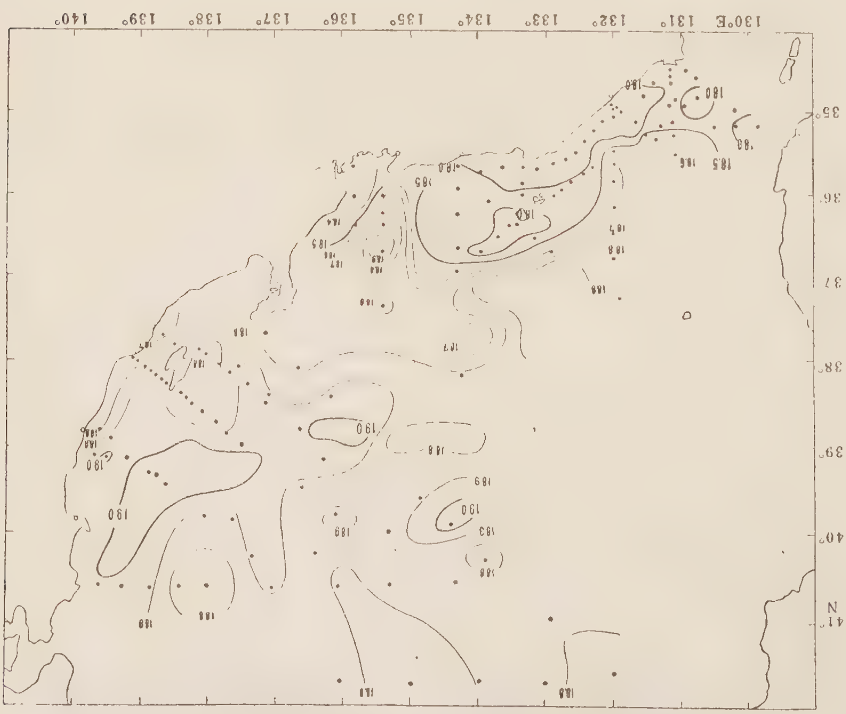


Fig. 6. Horizontal distribution of chlorinity (‰) at 25-metre layer.

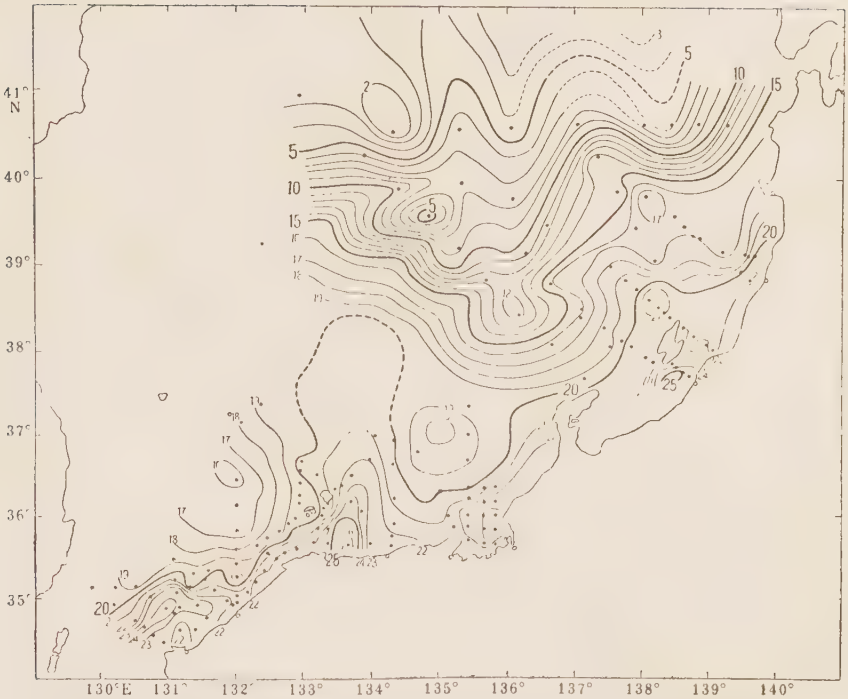


Fig. 7. Horizontal distribution of temperature (°C.) at 50-metre layer.



Fig. 8. Horizontal distribution of chlorinity (‰) at 50-metre layer.

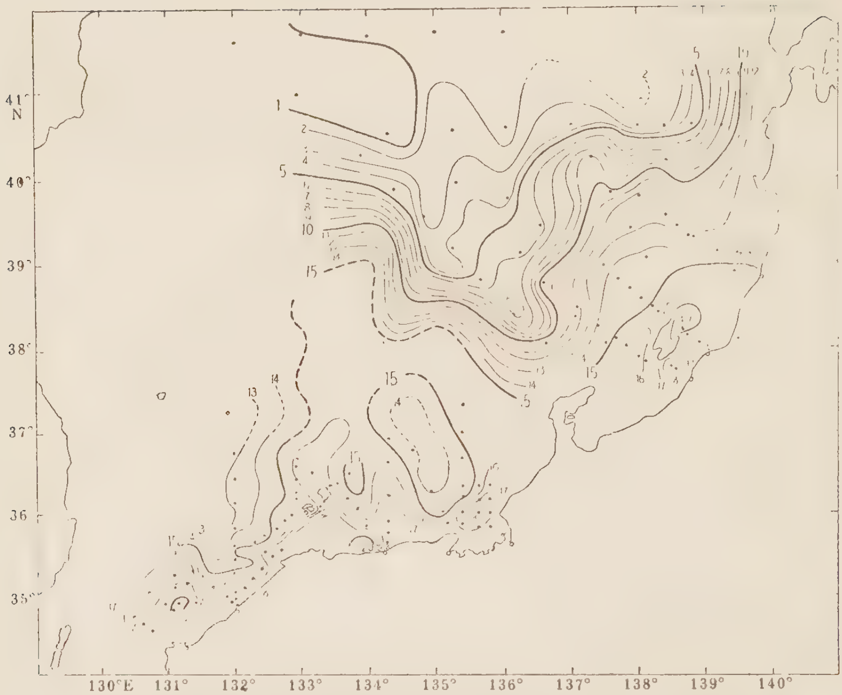


Fig 9. Horizontal distribution of temperature (°C.) at 100-metre layer.

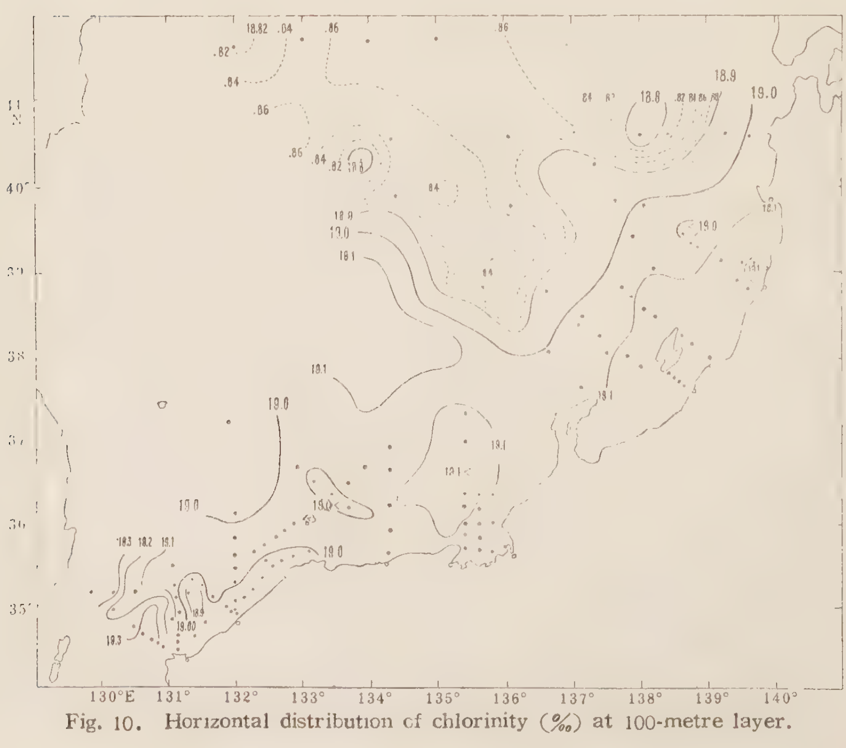


Fig. 10. Horizontal distribution of chlorinity (‰) at 100-metre layer.

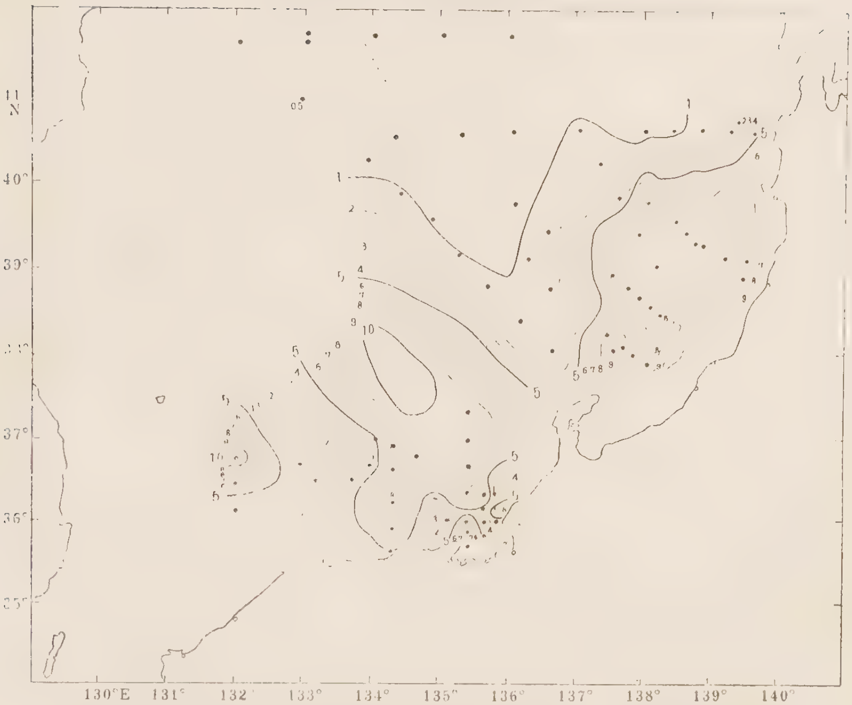


Fig. 11. Horizontal distribution of temperature (°C.) at 200-metre layer.

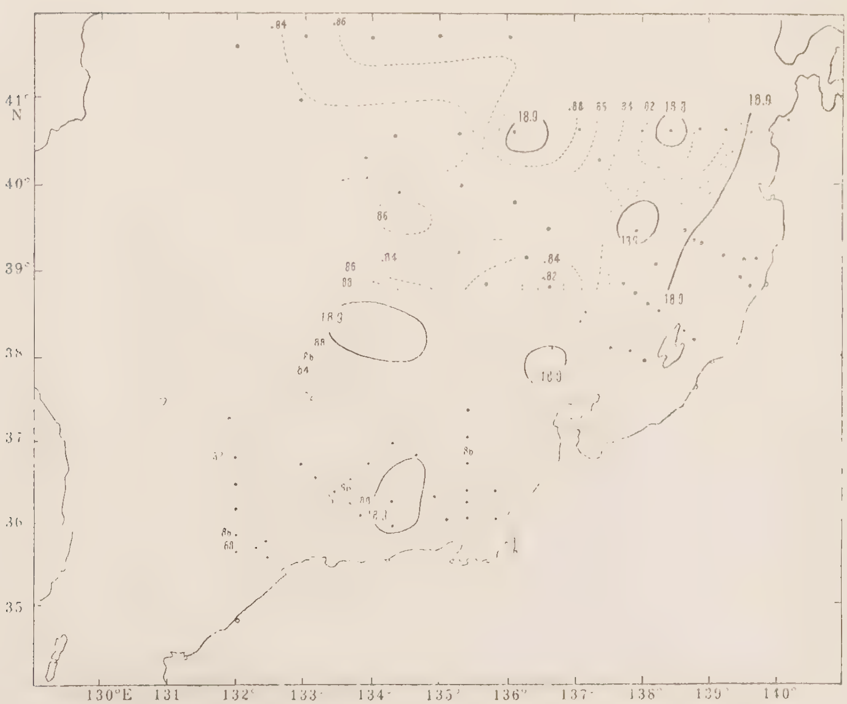


Fig. 12. Horizontal distribution of chlorinity (‰) at 200-metre layer.

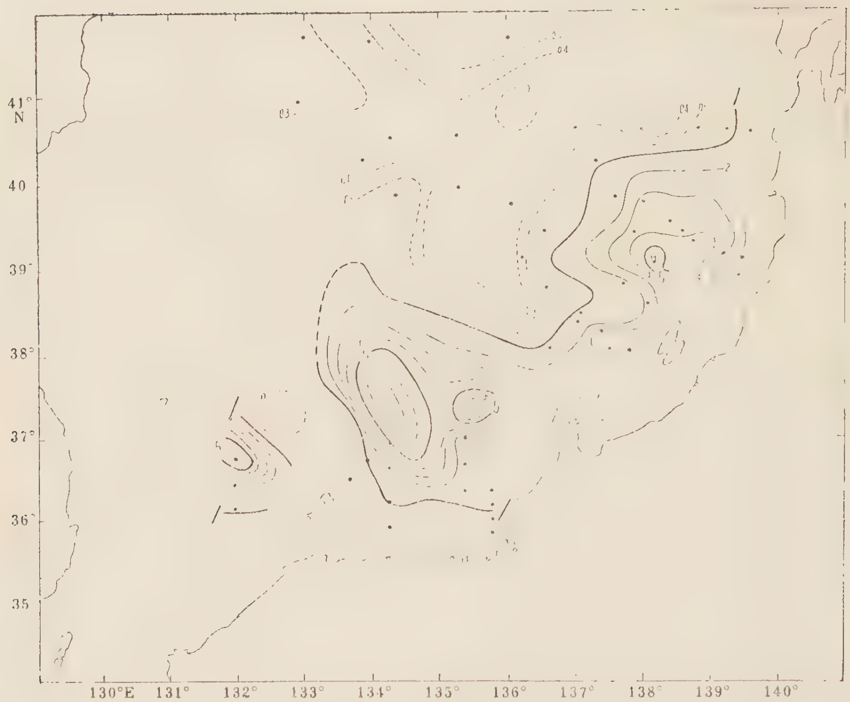


Fig. 13. Horizontal distribution of temperature (°C.) at 300-metre layer.

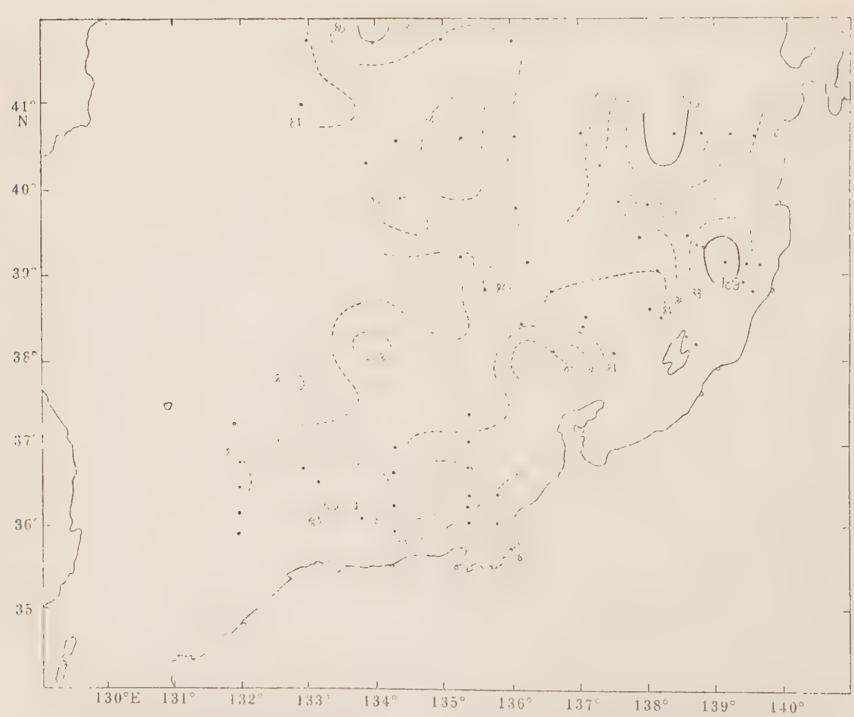


Fig. 14. Horizontal distribution of chlornity (‰) at 300-metre layer.

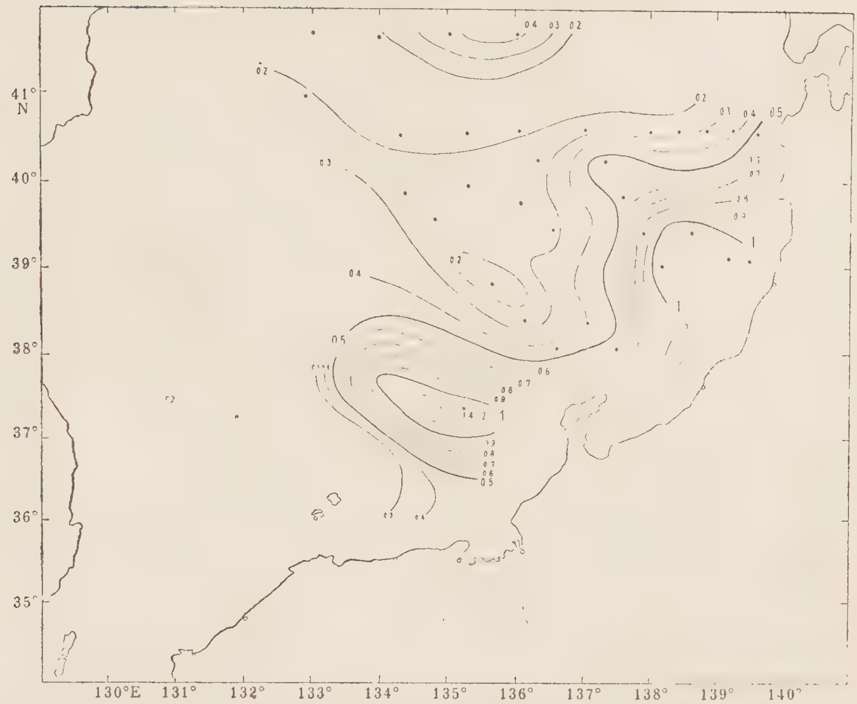


Fig. 15. Horizontal distribution of temperature (°C.) at 400-metre layer.

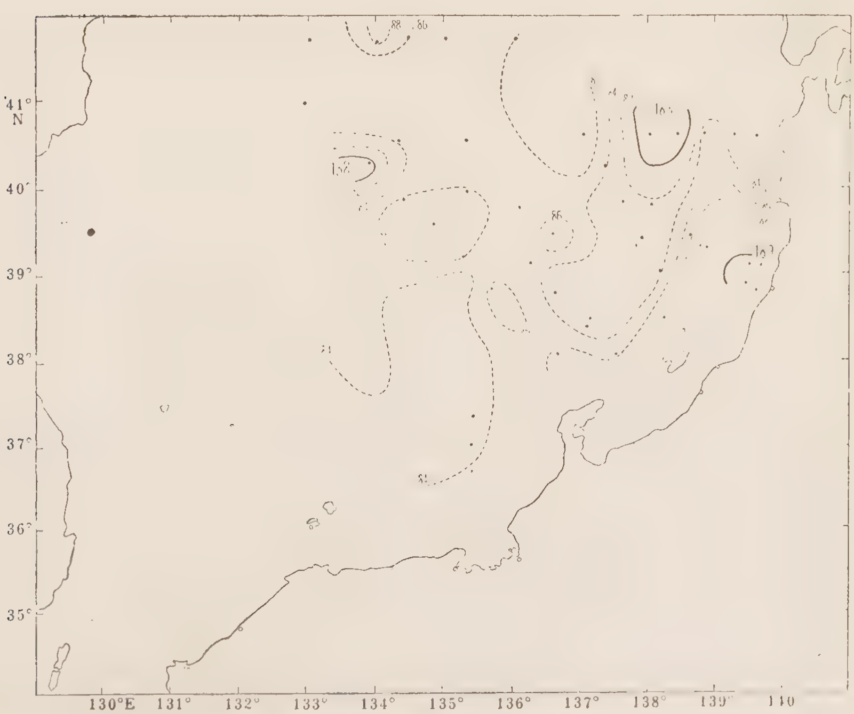


Fig. 16. Horizontal distribution of chlorinity (‰) at 400-metre layer.

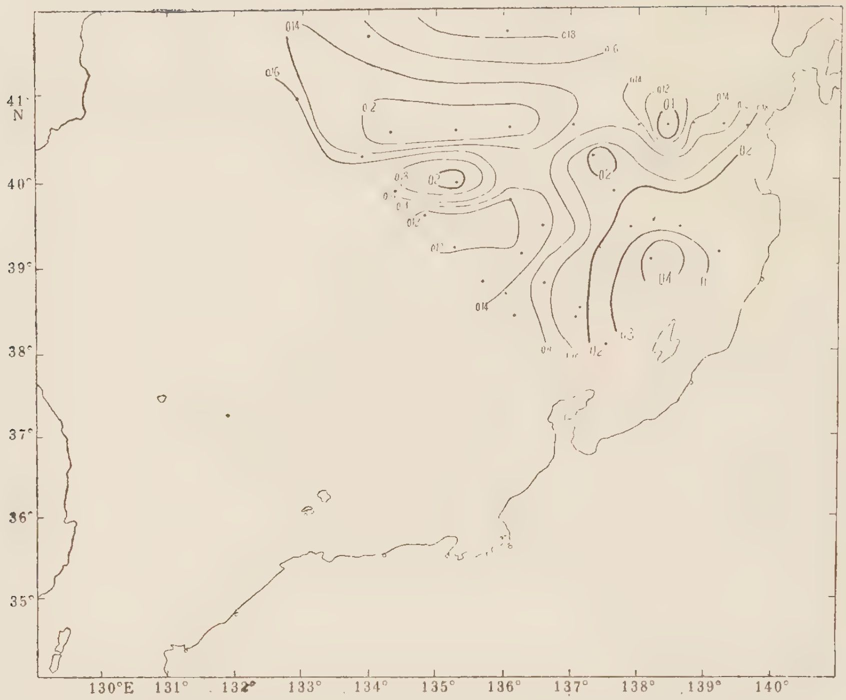


Fig. 17. Horizontal distribution of temperature (°C.) at 600-metre layer.

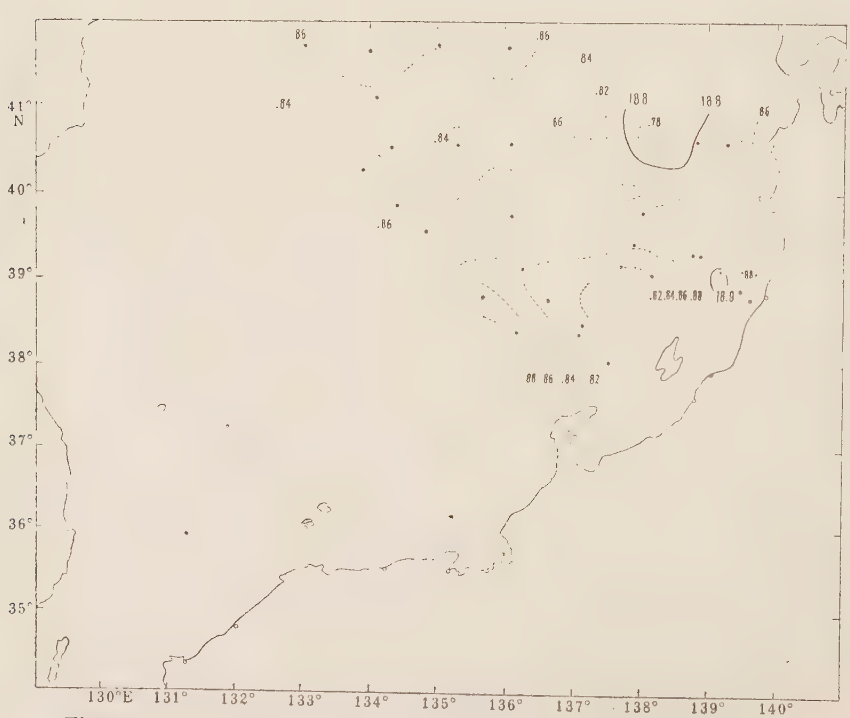


Fig. 18. Horizontal distribution of chlorinity (‰) at 600-metre layer.

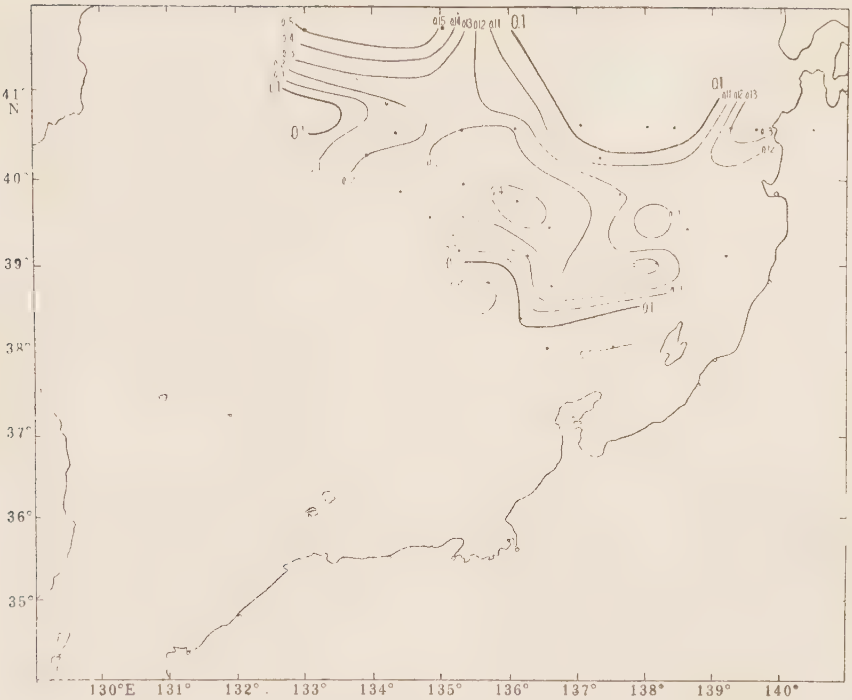


Fig. 19. Horizontal distribution of temperature (°C.) at 1,000-metre layer.

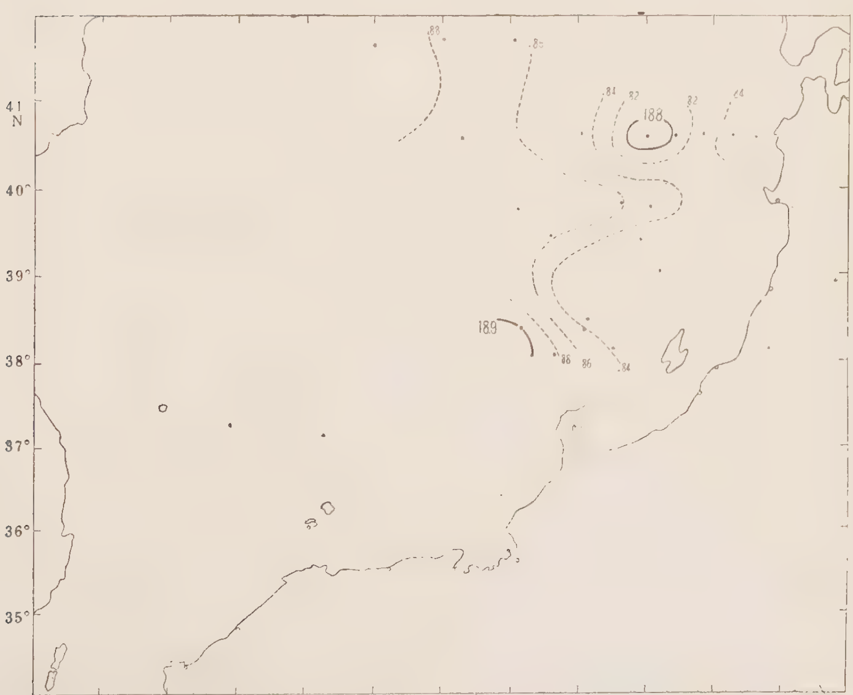


Fig. 20. Horizontal distribution of chlorinity (‰) at 1,000-metre layer.

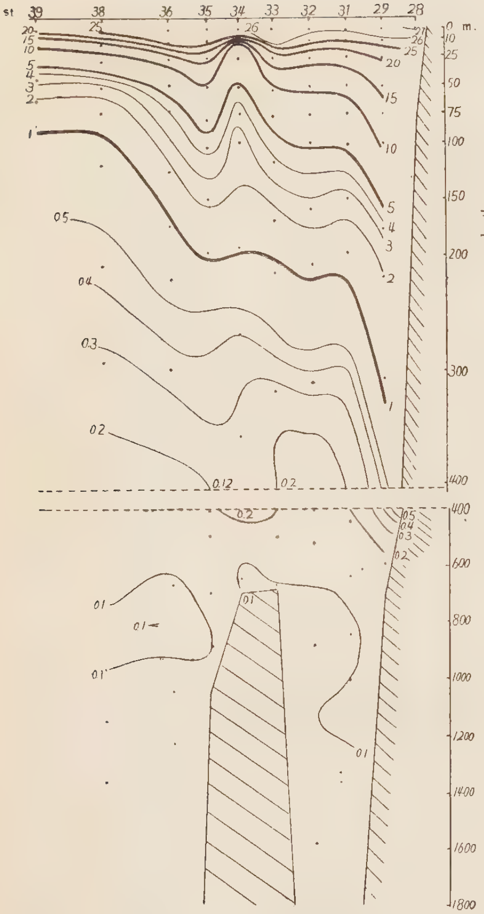


Fig. 21. Distribution of water temperature(°C.) in a vertical section north-west of Rokugo Saki, Noto Peninsula.

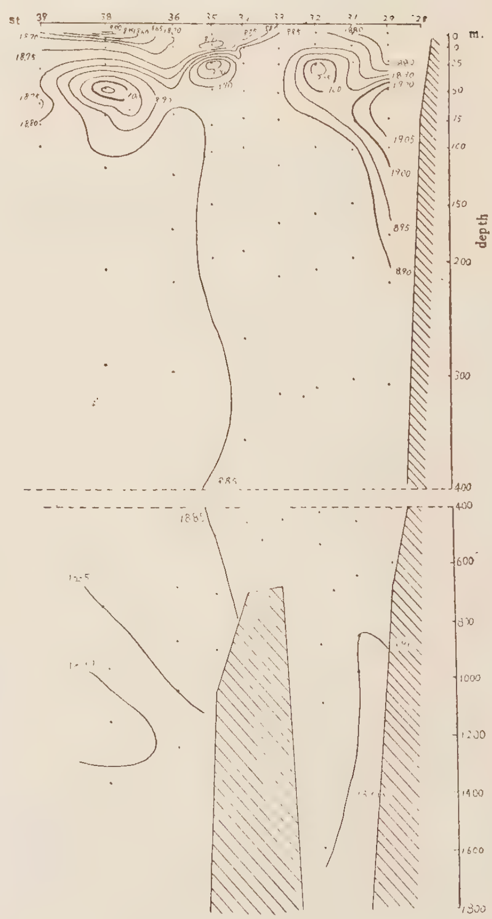


Fig. 22. Distribution of chlorinity (‰) in a vertical section north-west of Rokugo Saki Noto Peninsula.

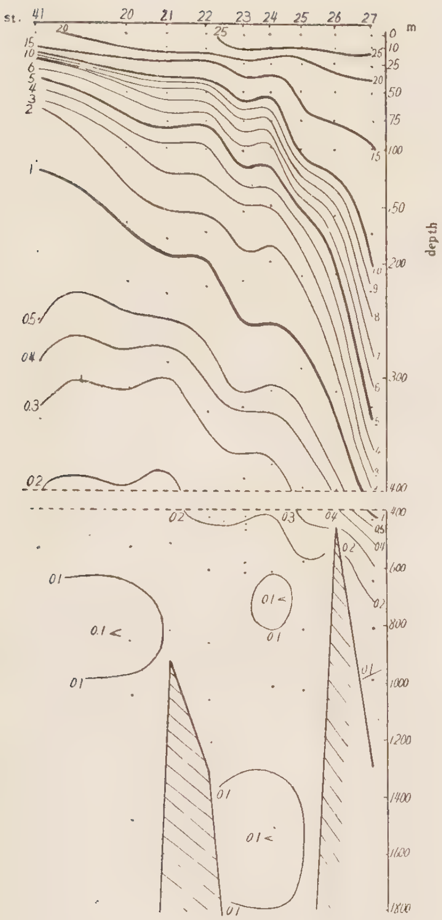


Fig. 23. Distribution of water temperature(°C.) in a vertical section north-west of Sawa Saki, Sado Island.

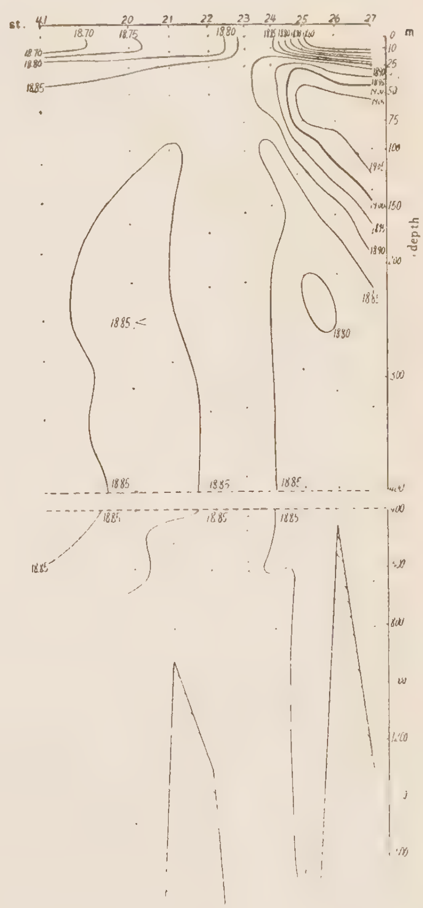


Fig. 24. Distribution of chlorinity (‰) in a vertical section north-west of Sawa Saki, Sado Island.

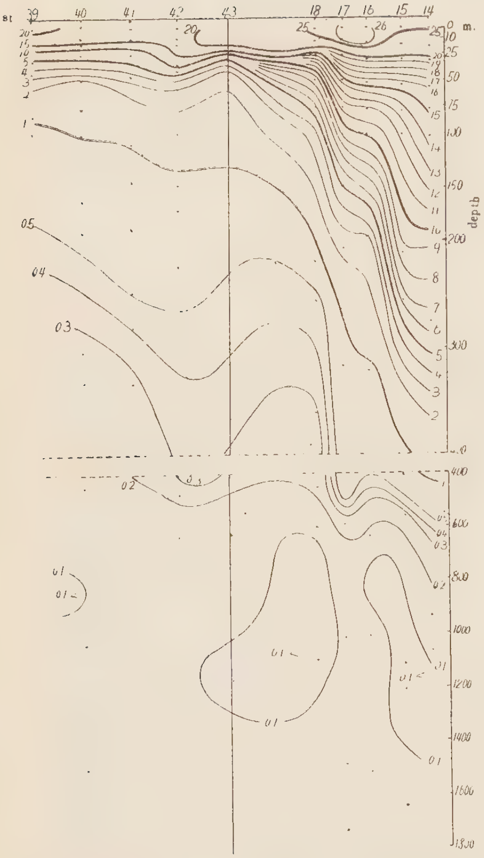


Fig. 25. Distribution of water temperature(°C.) in a vertical section north-west of Niigata.

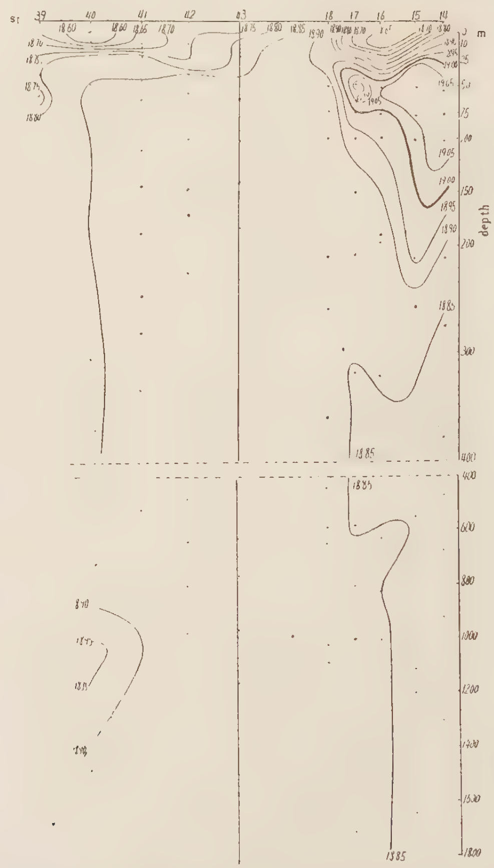


Fig. 26. Distribution of chlorinity (‰) in a vertical section north-west of Niigata.

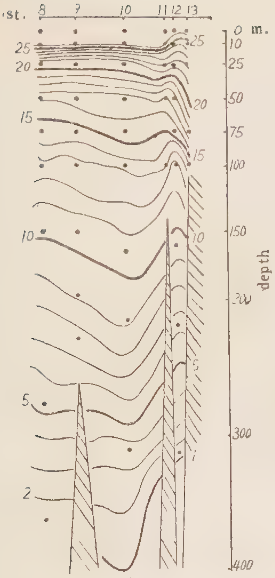


Fig. 27. Distribution of water temperature (°C.) in a vertical section north-west of Kamo, Yamagata Pref..

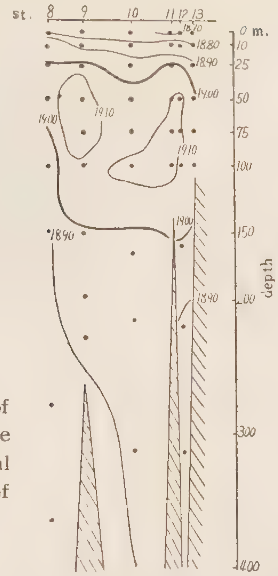


Fig. 28. Distribution of chlorinity (‰) in a vertical section north-west of Kamo, Yamagata Pref..

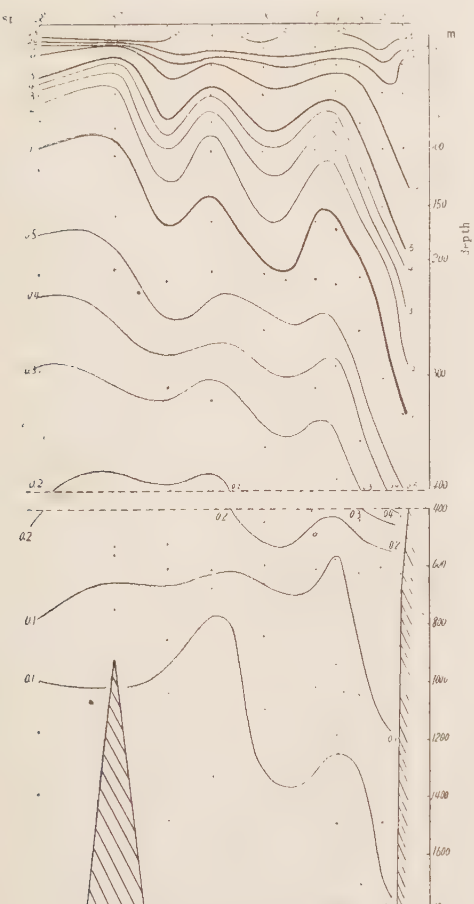


Fig. 29. Distribution of wtaer temperature(°C.) in a vertical section west of Henashi Saki, Aomori Pref..

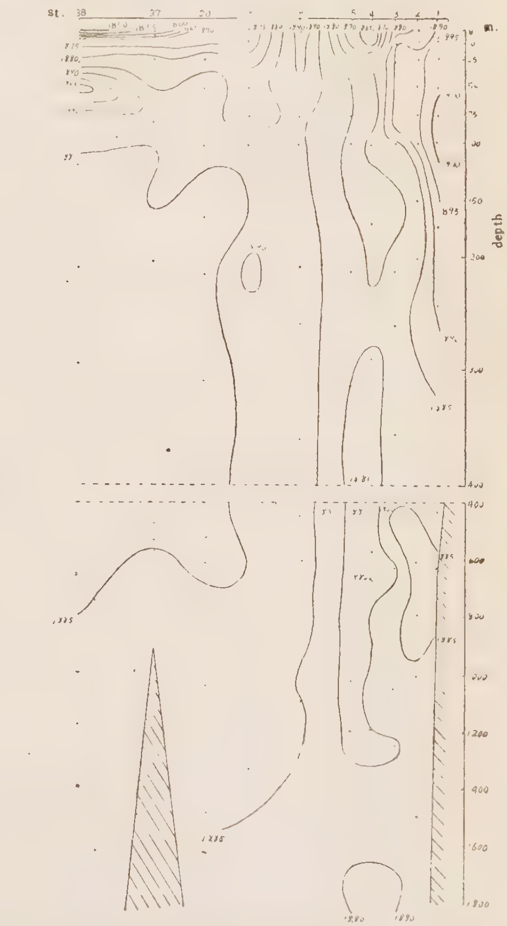


Fig. 30. Distribution of chlorinity (‰) in a vertical section west of Henashi Saki, Aomori Pref..



Fig. 31. Horizontal distribution of oxygen content (cc./L) at 10-metre layer.

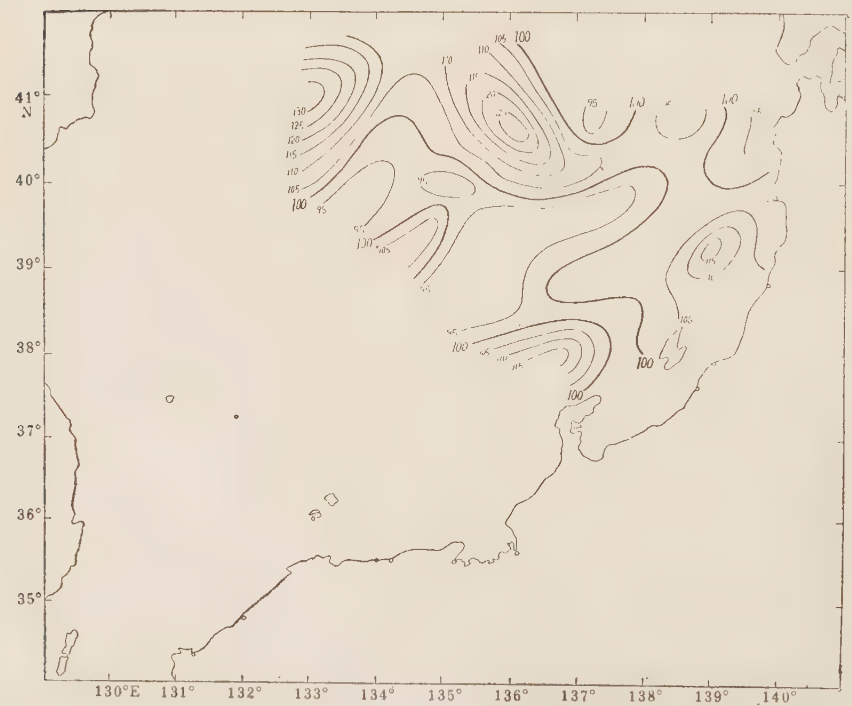


Fig. 32. Horizontal distribution of oxygen saturation (%) at 10-metre layer.

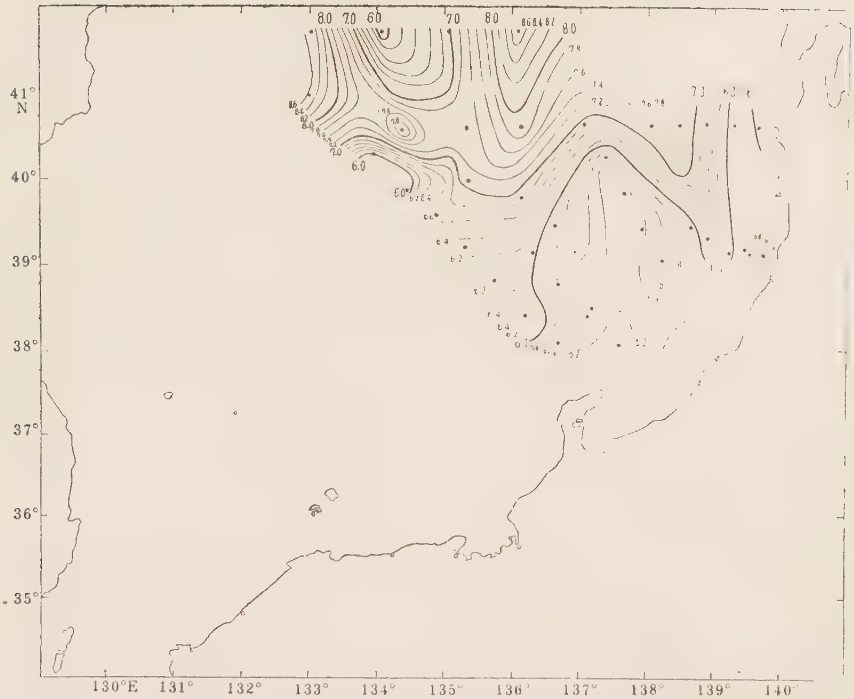


Fig. 33. Horizontal distribution of oxygen content (cc./L) at 25-metre layer.

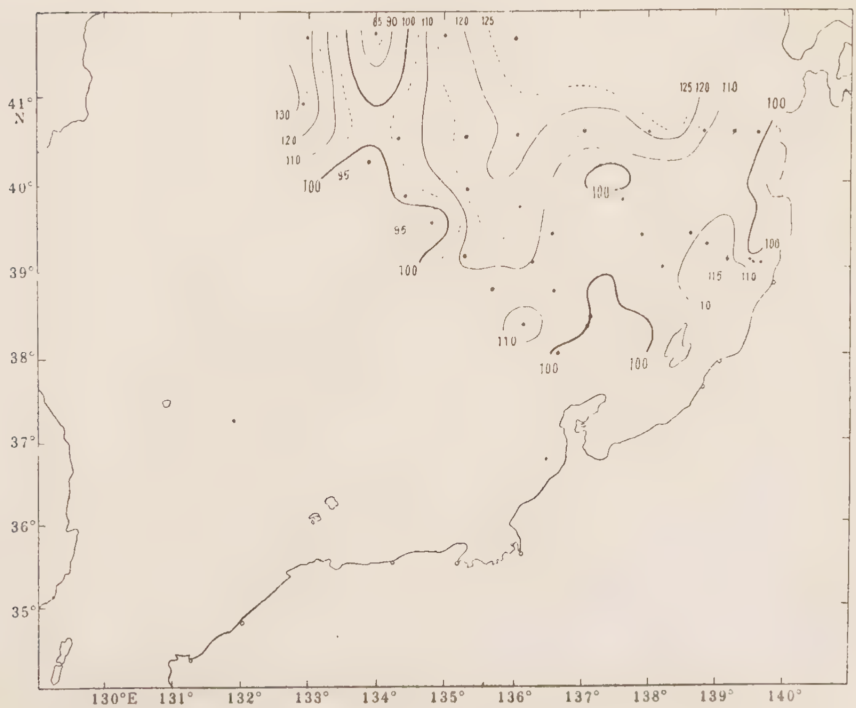


Fig. 34. Horizontal distribution of oxygen saturation (%) at 25-metre layer.



Fig. 35. Horizontal distribution of oxygen content (cc./L) at 50-metre layer.

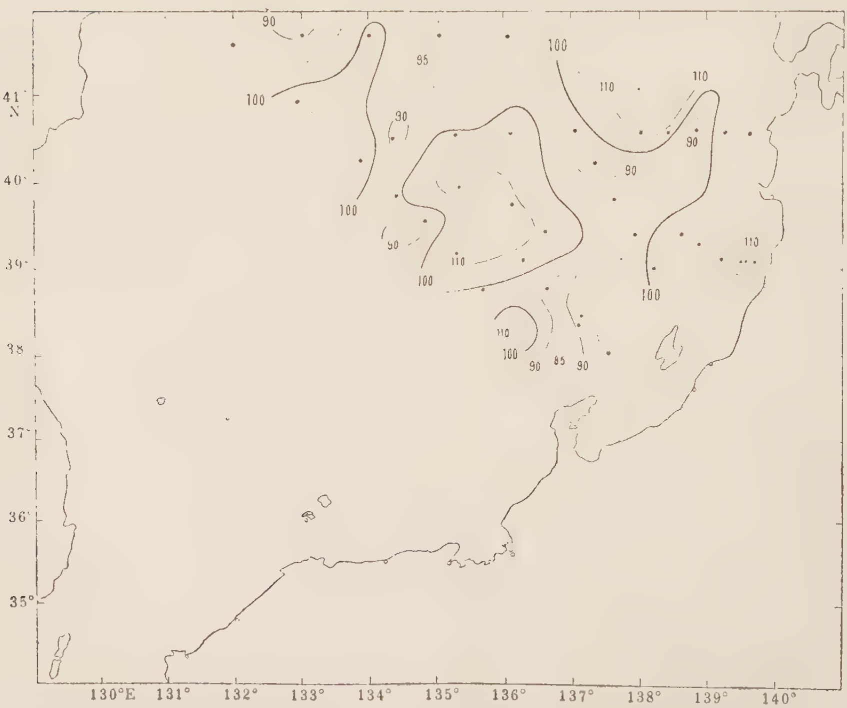


Fig. 36. Horizontal distribution of oxygen saturation (%) at 50-metre layer.

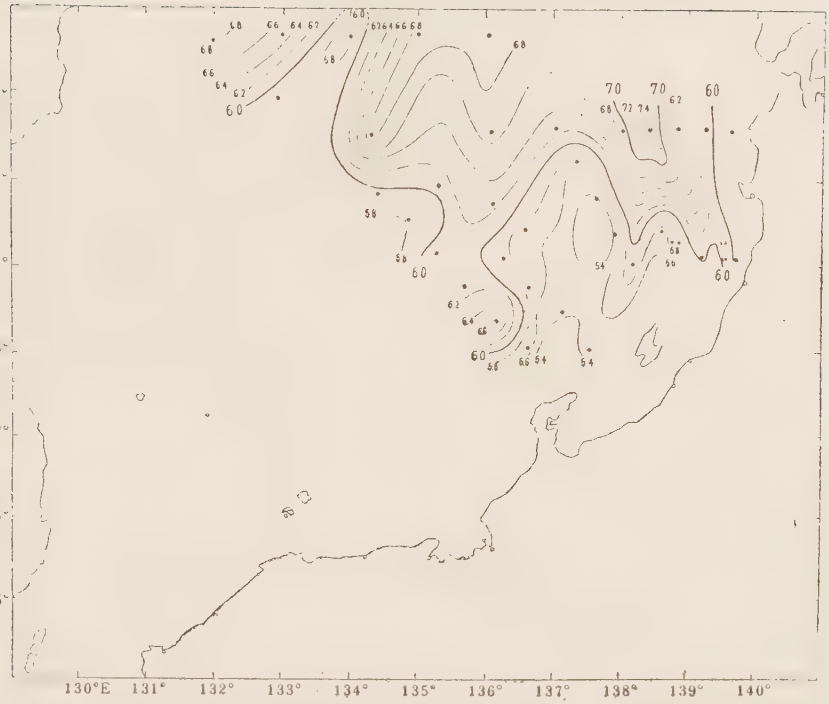


Fig. 37. Horizontal distribution of oxygen content (cc./L) at 100-metre layer.

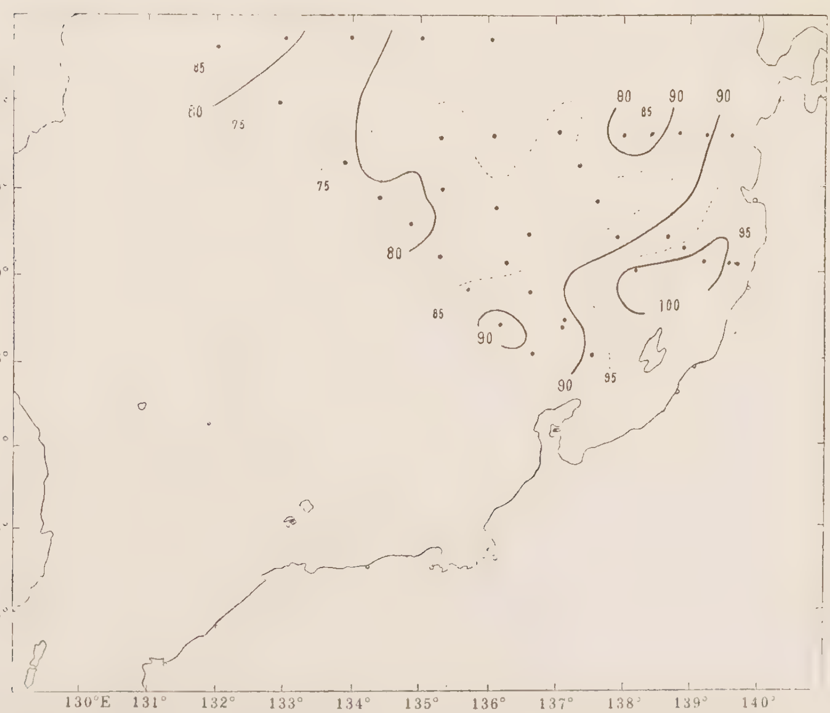


Fig. 38. Horizontal distribution of oxygen saturation (%) at 100-metre layer.

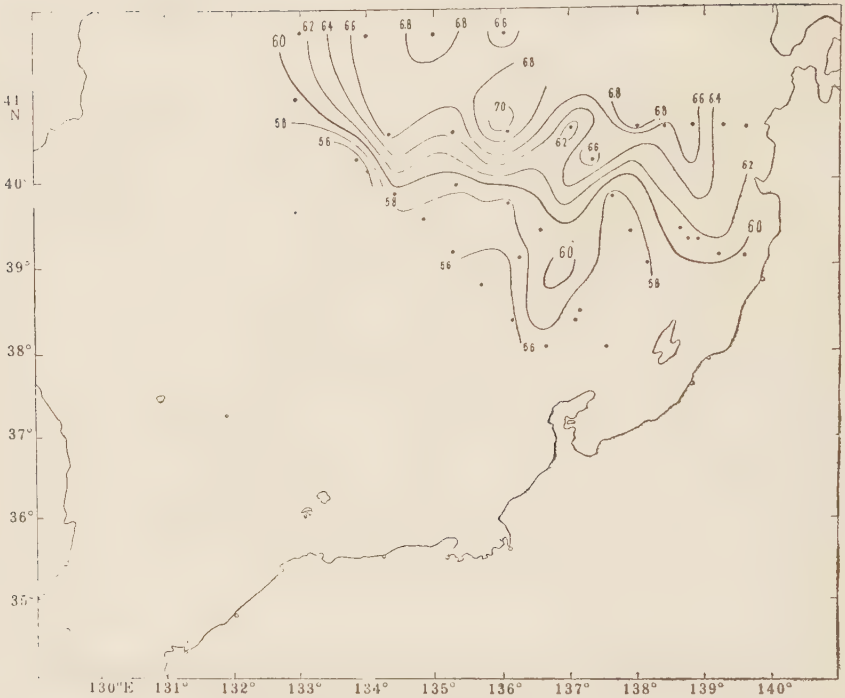


Fig. 39. Horizontal distribution of oxygen content (cc./L) at 200-metre layer.

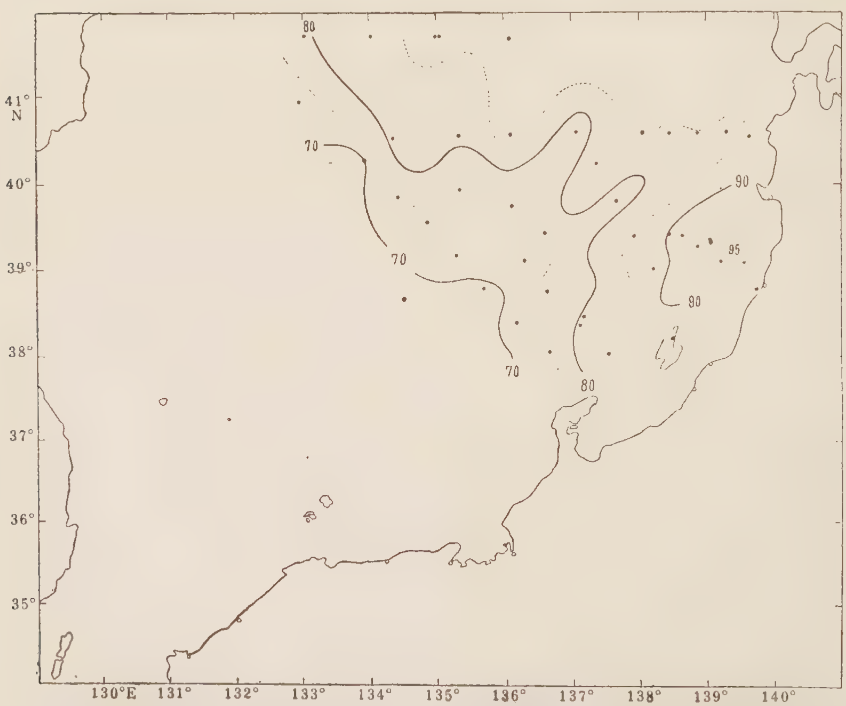


Fig. 40. Horizontal distribution of oxygen saturation (%) at 200-metre layer.

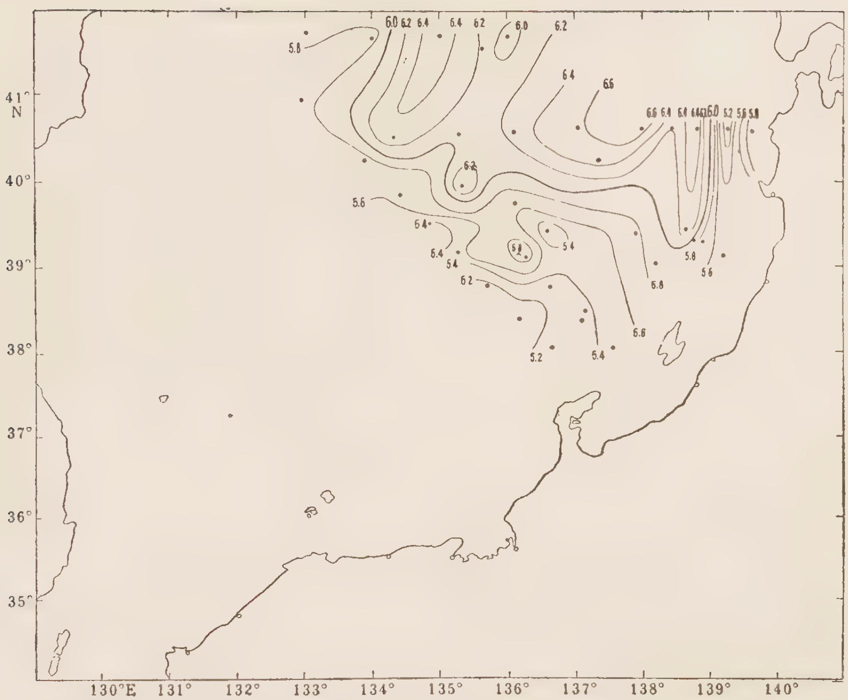


Fig. 41. Horizontali distribution of oxygen content (cc./L) at 300-metre layer.

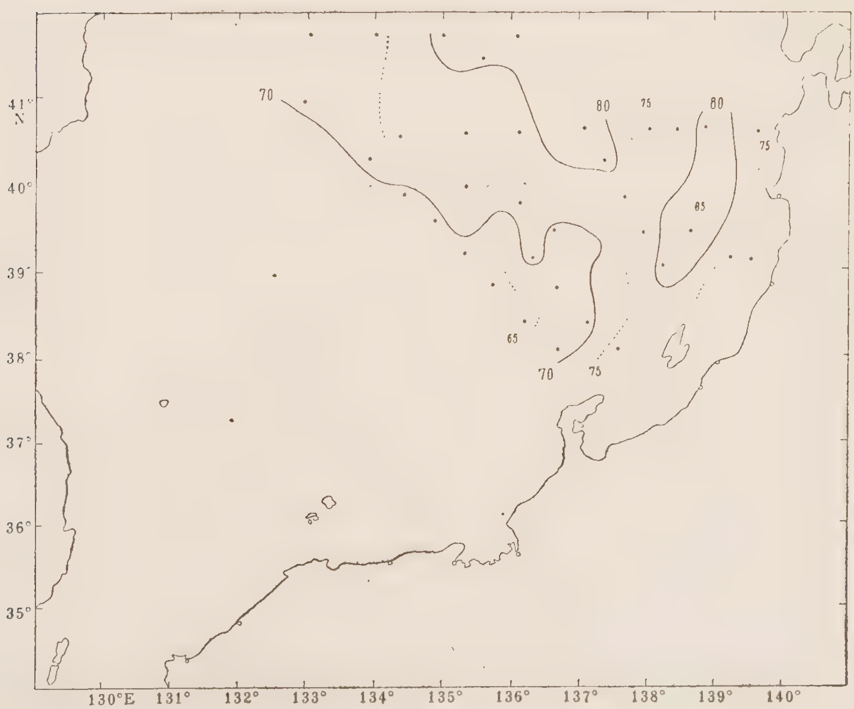


Fig. 42. Horizontal distribution of oxygen saturation (%) at 300-metre layer.

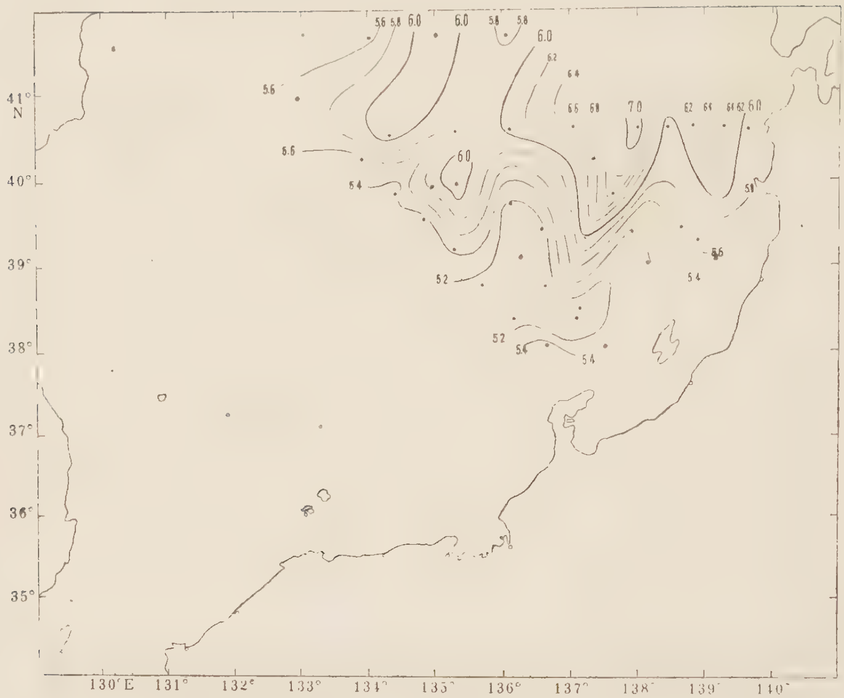


Fig. 43. Horizontal distribution of oxygen content (cc./L) at 400-metre layer.



Fig. 44. Horizontal distribution of oxygen saturation (%) at 400-metre layer.

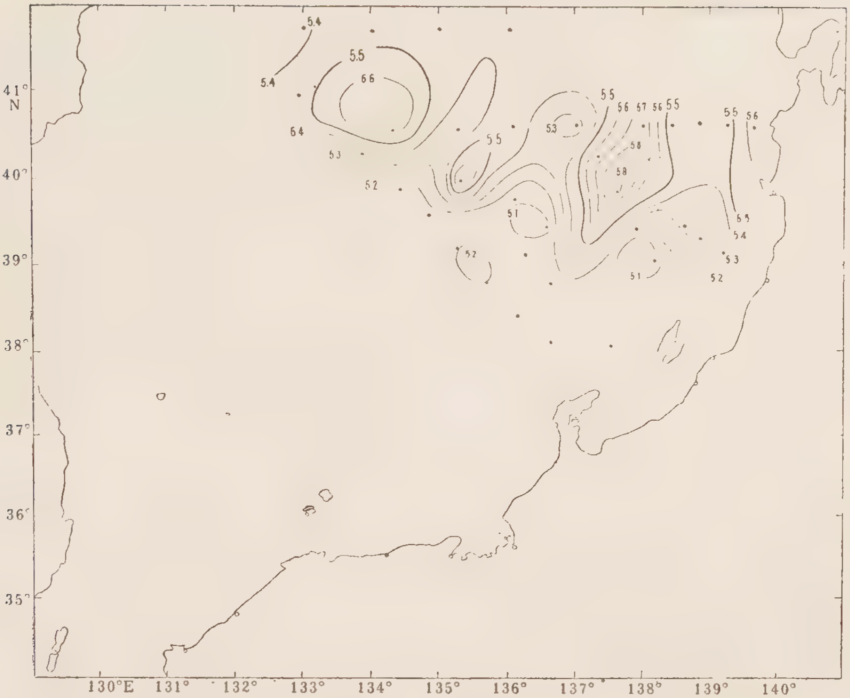


Fig. 45. Horizontal distribution of oxygen content (cc./L) at 600-metre layer

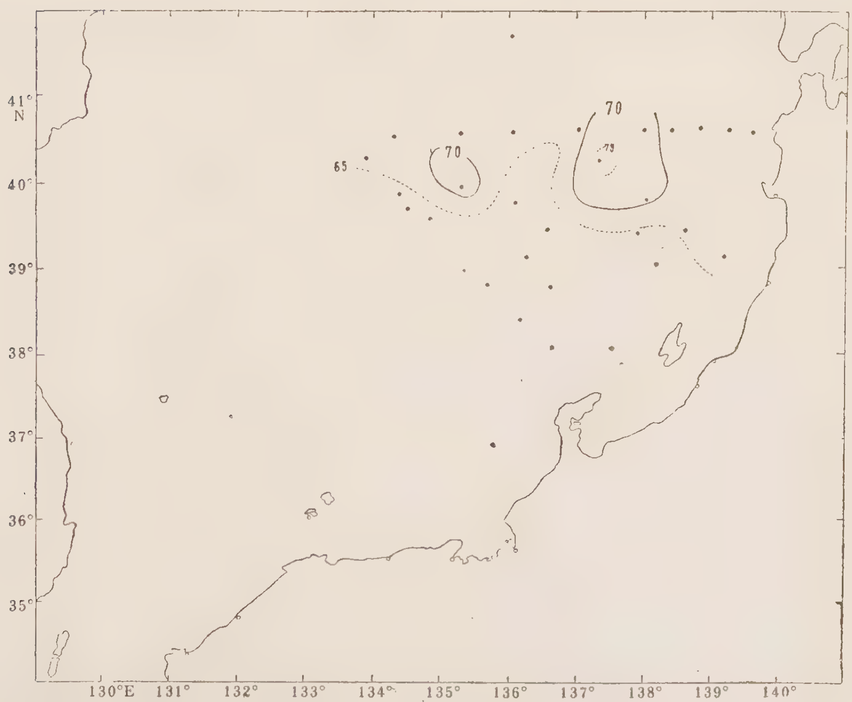


Fig. 46. Horizontal distribution of oxygen saturation (%) at 600-metre layer.

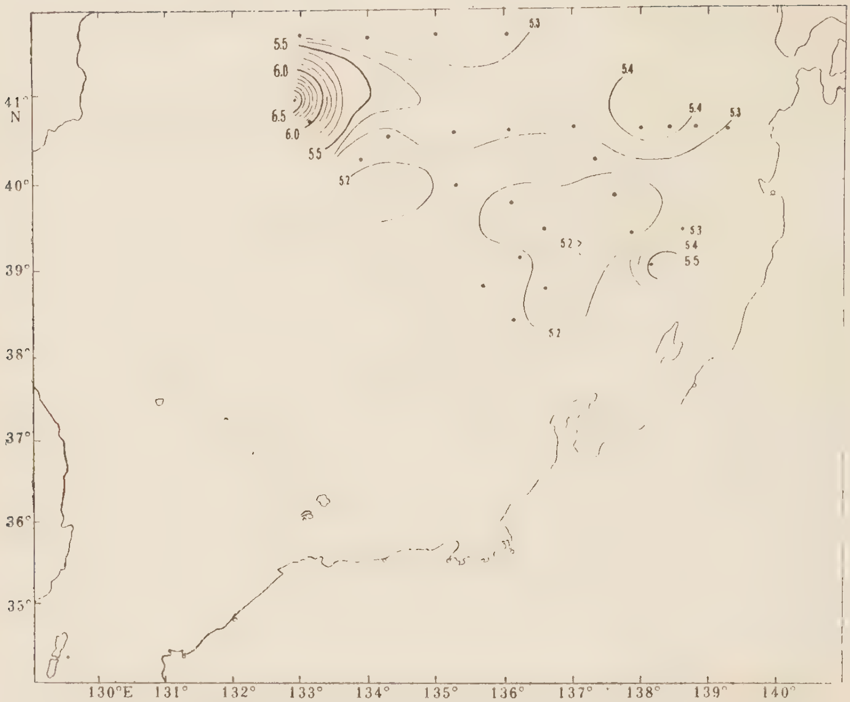


Fig. 47. Horizontal distribution of oxygen content (cc./L) at 1,000-metre layer.

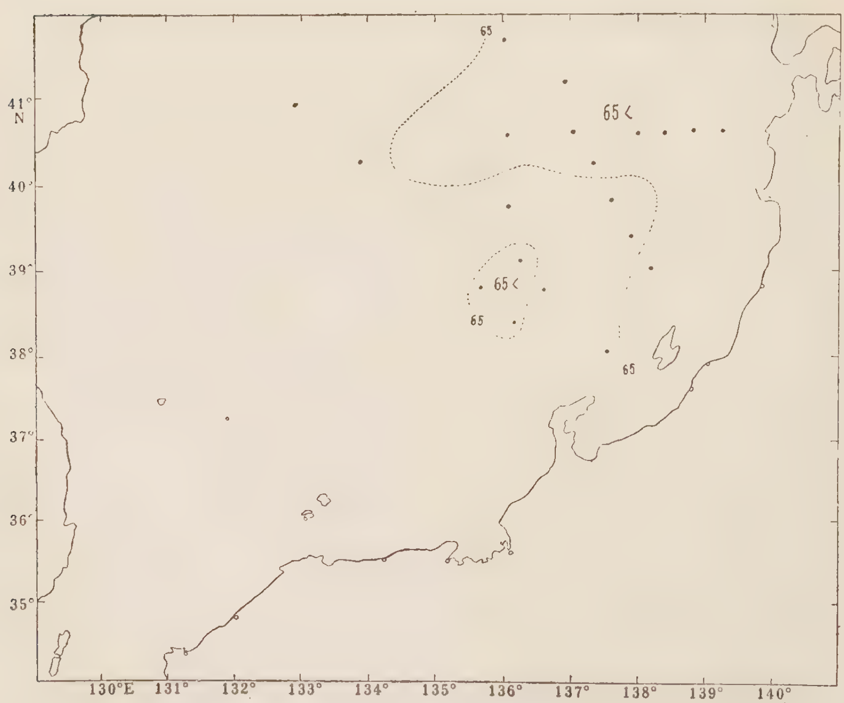


Fig. 48. Horizontal distribution of oxygen saturation (%) at 1,000-metre layer.

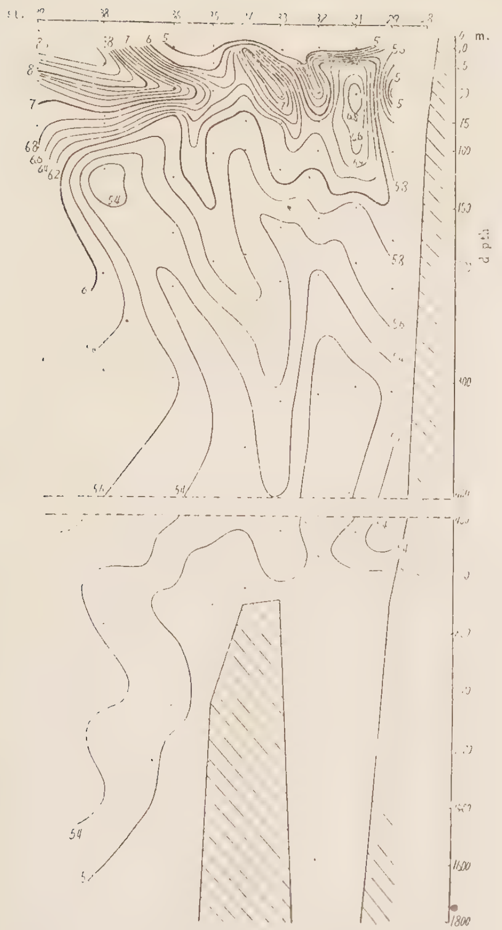


Fig. 49. Distribution of oxygen content (cc./L) in a vertical section north-west of Rokugo Saki, Noto Peninsula.

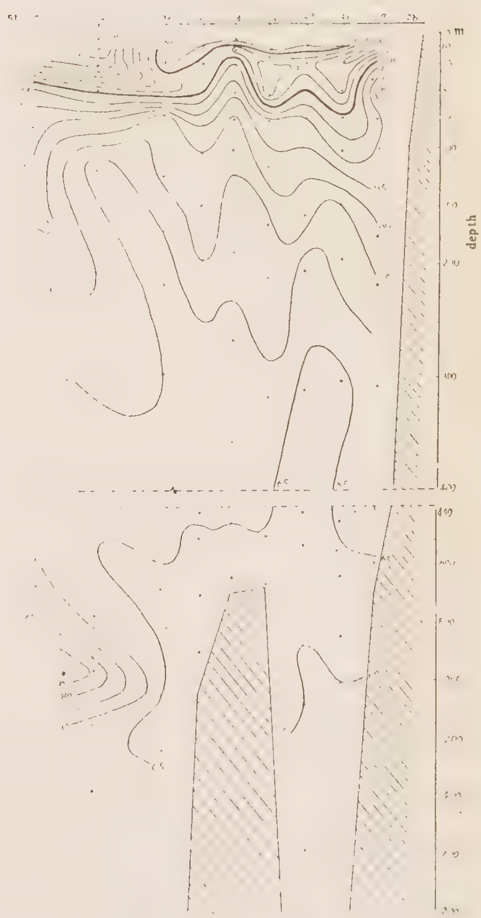


Fig. 50. Distribution of oxygen saturation (%) in a vertical section north-west of Rokugo Saki, Noto Peninsula.

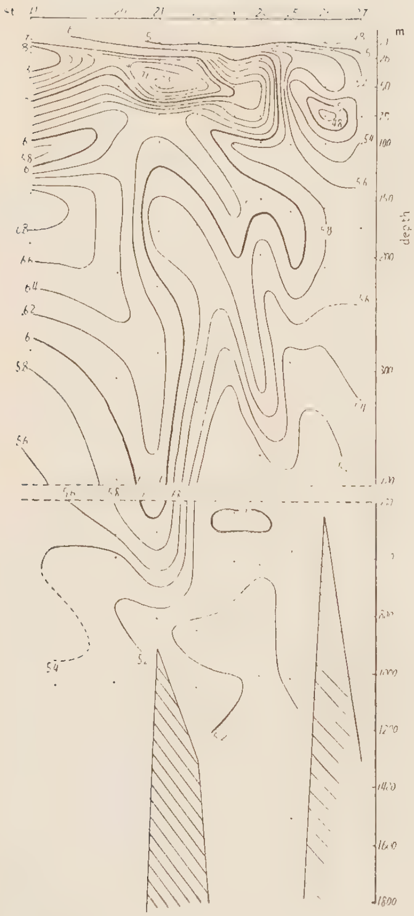


Fig. 51. Distribution of oxygen content (cc./L) in a vertical section north-west of Sawa Saki, Sado Island.

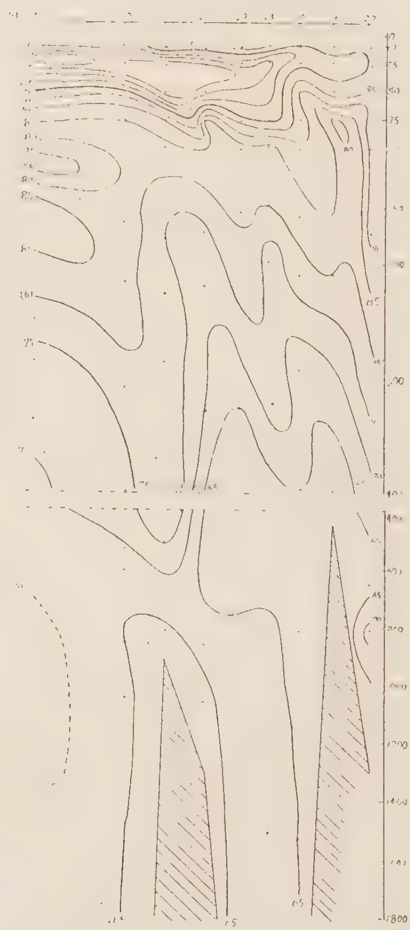


Fig. 52. Distribution of oxygen saturation (%) in a vertical section north-west of Sawa Saki, Sado Island.

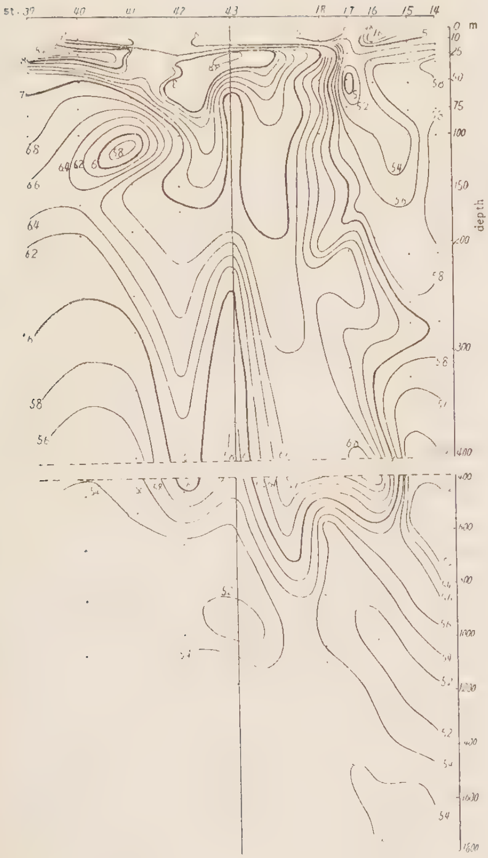


Fig. 53. Distribution of oxygen content (cc./L) in a vertical section north-west of Niigata.

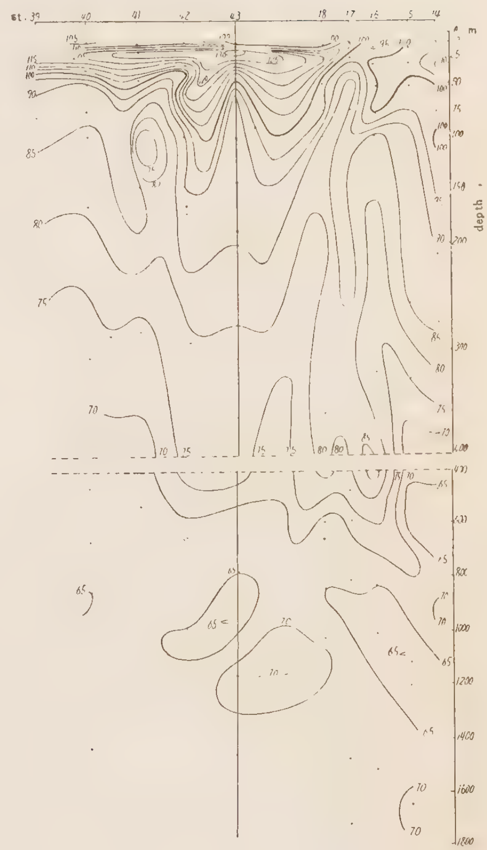


Fig. 54. Distribution of oxygen saturation (%) in a vertical section north-west of Niigata.

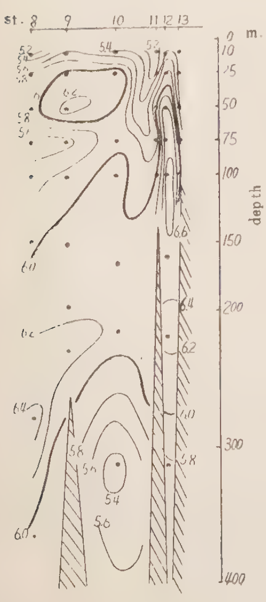


Fig. 55. Distribution of oxygen content(cc./L)in a vertical section north-west of Kamo, Yamagata Pref.,

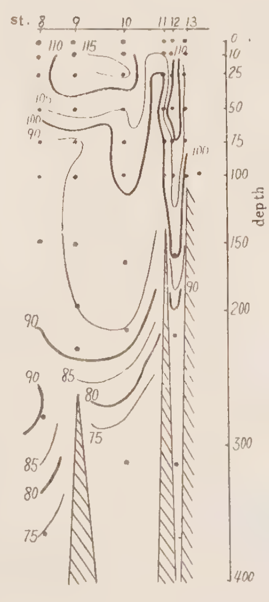


Fig. 56. Distribution of oxygen saturation (%) in a vertical section north-west of Kamo, Yamagata Pref..



Fig. 57. Distribution of oxygen content (cc./L) in a vertical section north-west of Henashi Saki, Aomori Pref..



Fig. 58. Distribution of oxygen saturation (%) in a vertical section north-west of Henashi Saki, Aomori Pref..

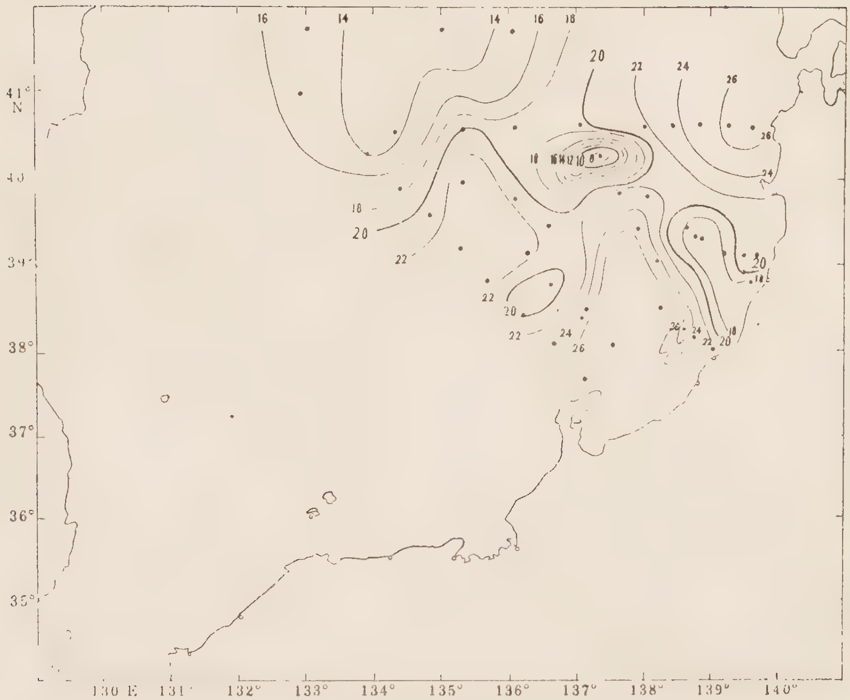


Fig. 59. Transparency of the water (m.).

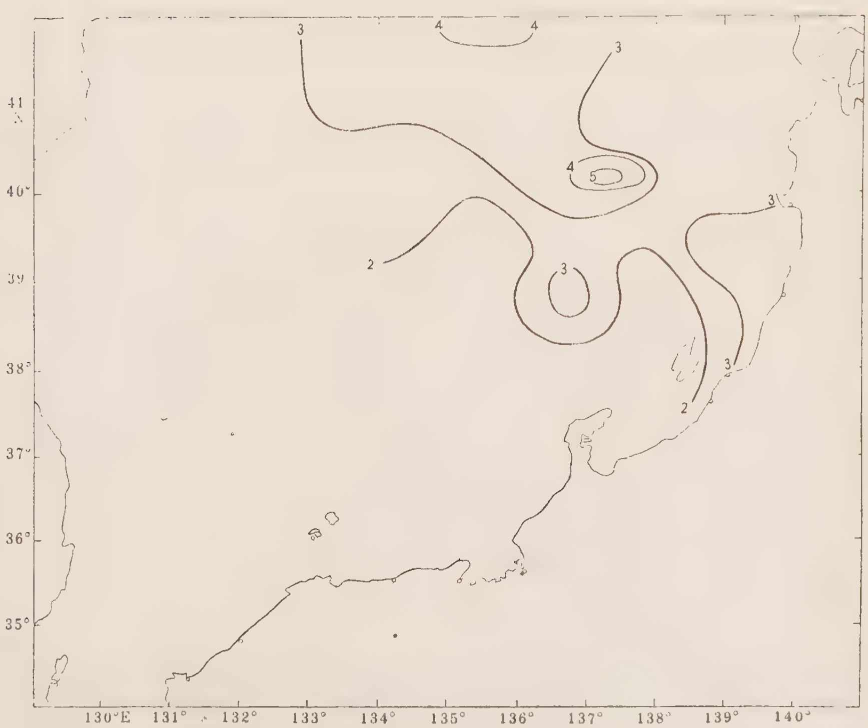


Fig. 60. Color of the water (Forel's scale.)

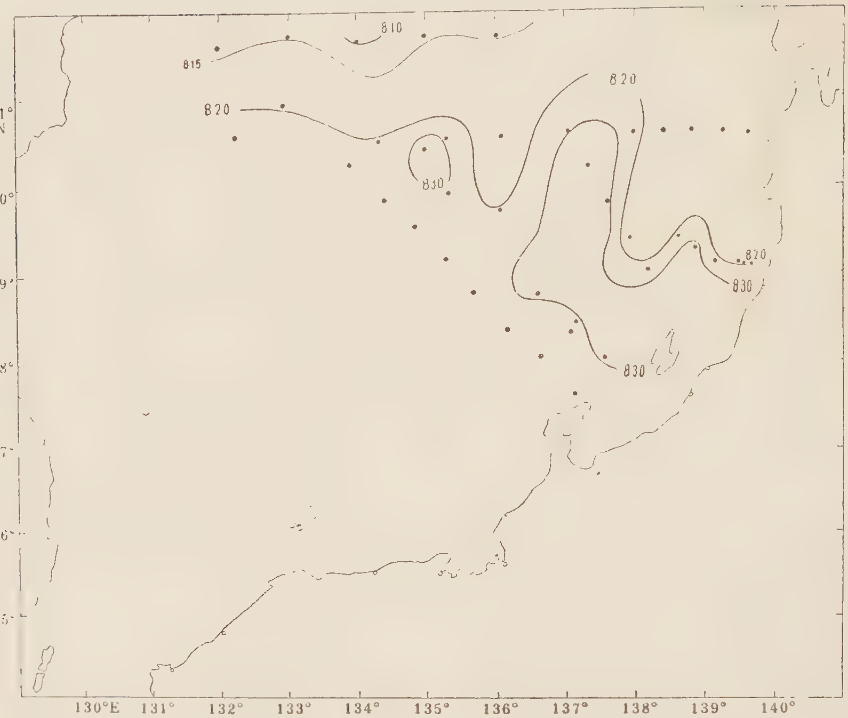


Fig. 61. Horizontal distribution of hydrogen ion concentration at 0-metre layer.

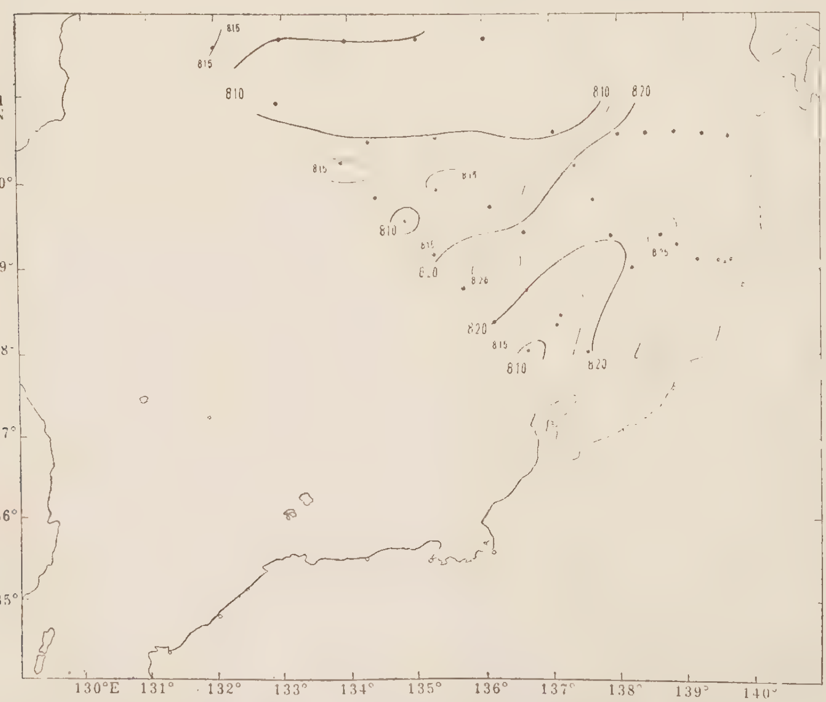


Fig. 62. Horizontal distribution of hydrogen ion concentration at 25-metre layer.

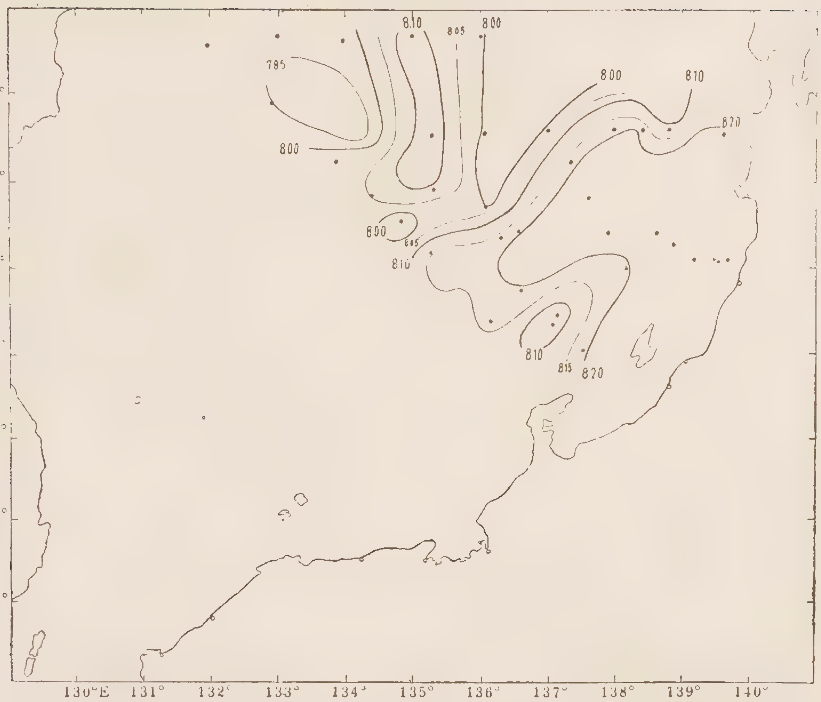


Fig. 63. Horizontal distribution of hydrogen ion concentration at 50-metre layer.

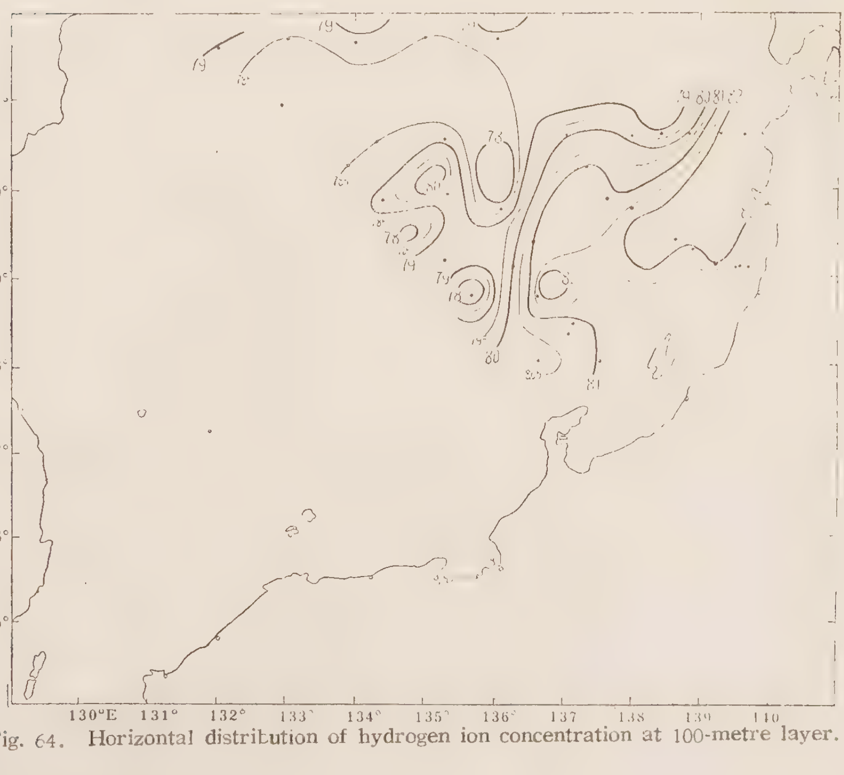


Fig. 64. Horizontal distribution of hydrogen ion concentration at 100-metre layer.

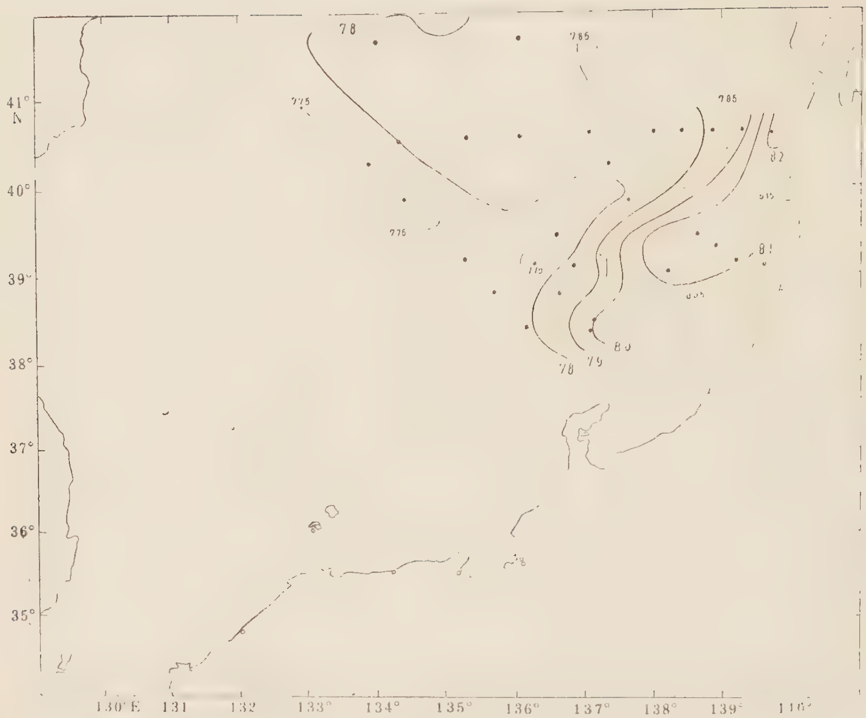


Fig. 65. Horizontal distribution of hydrogen ion concentration at 200-metre layer.

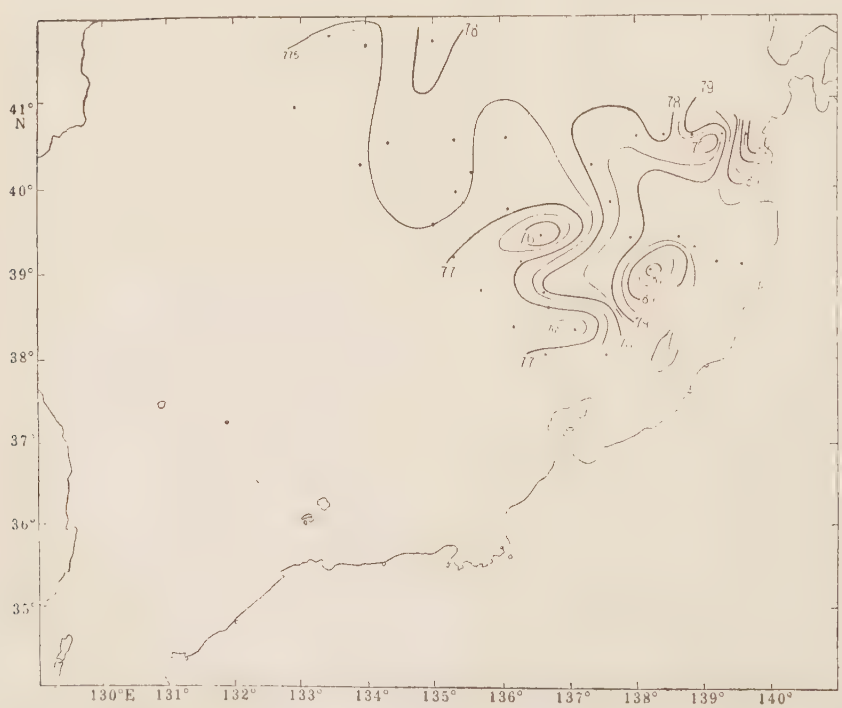


Fig. 66. Horizontal distribution of hydrogen ion concentration at 300-metre layer.

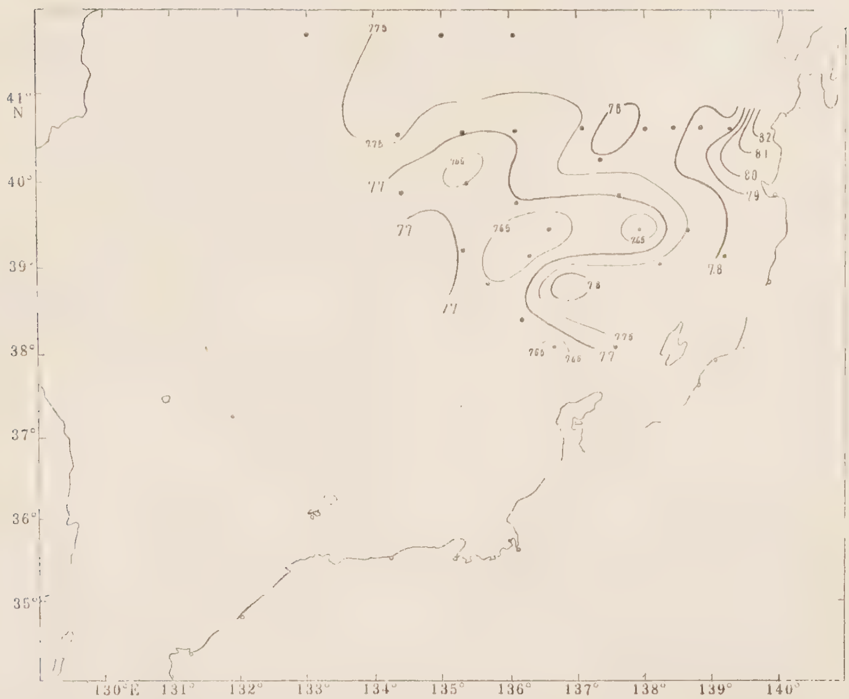


Fig. 67. Horizontal distribution of hydrogen ion concentration at 400 metre layer.



Fig. 68. Horizontal distribution of hydrogen ion concentration at 600-metre layer.

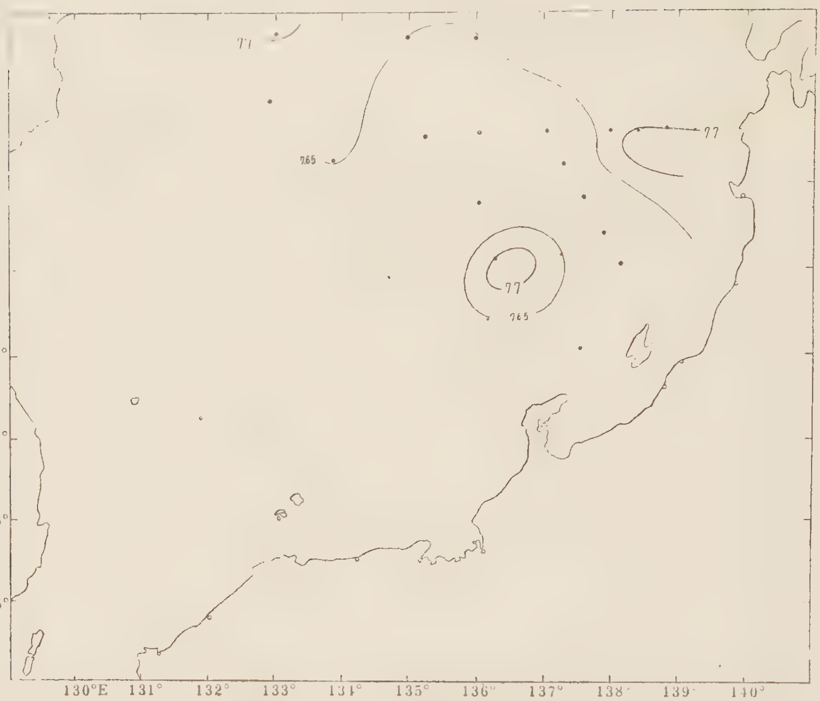


Fig 69. Horizontal distribution of hydrogen ion concentration at 1,000-metre layer.

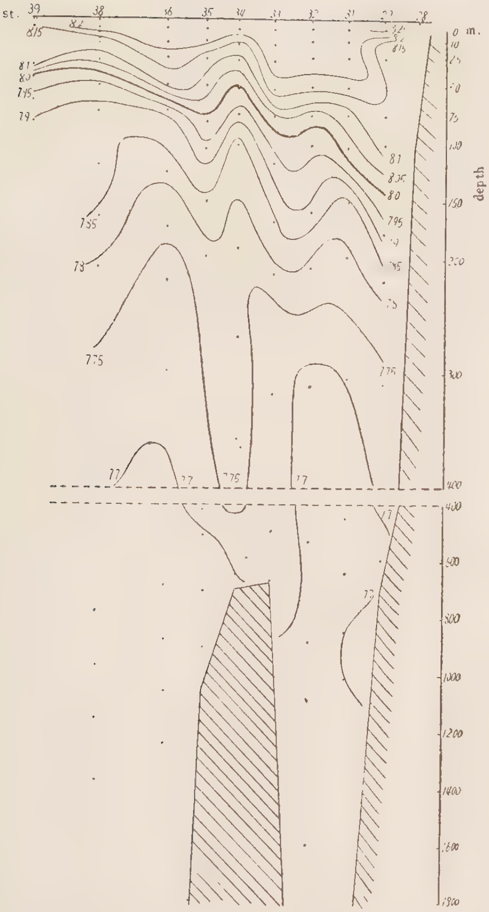


Fig. 70. Distribution of hydrogen ion concentration in a vertical section north-west of Rokugo Noto Peninsula.

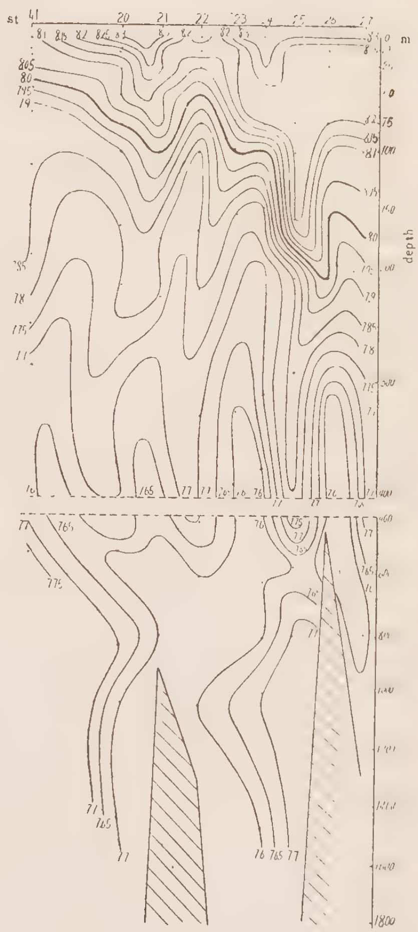


Fig. 71. Distribution of hydrogen ion concentration in a vertical section north-west of Sawa Saki, Sado Island.

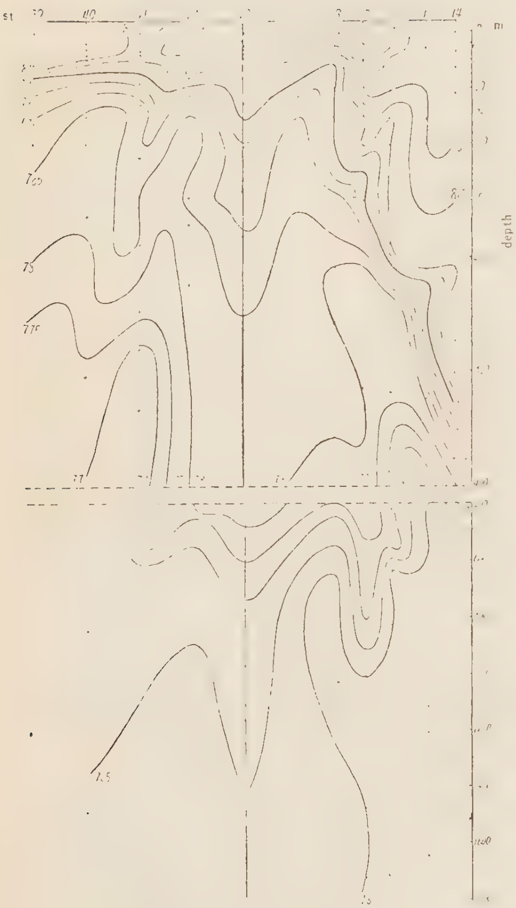


Fig. 72. Distribution of hydrogen ion concentration in a vertical section north-west of Niigata.

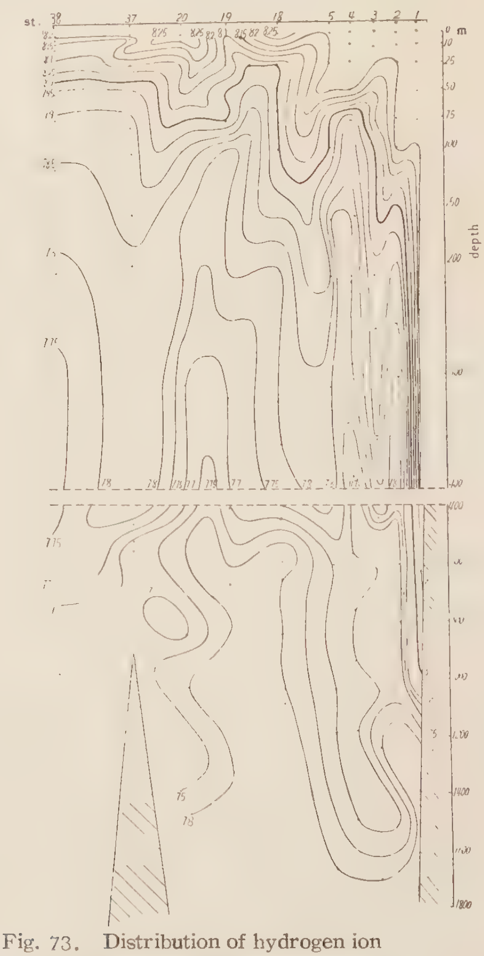


Fig. 73. Distribution of hydrogen ion concentration in a vertical section north-west of Henashi Saki, Aomori Pref..

第2章　日本海における対馬暖流の変動

Chapter 2　The Yearly Oceanographical Changes of the Tsushima Current in the Japan Sea.

I　はしがき

第1章 table 1 に記したような大規模観測の諸報告において述べられているとおり，日本海の海流系は Liman 寒流系と対馬暖流系とからなり，対馬暖流系はさらに対馬海峡より3分枝に分れて日本海を北上する。

これらの海流の流路は非常に変化に富み，特に対馬暖流第2分枝・第3分枝の変化は大いに注目されているものである。すなはち，かかる暖流各分枝の流路および流量の変化は沿岸漁況・漁場形成などに大きな影響をもつている。著者ら（1953・1956）はさきに暖流流路や勢力の変化を示す指標として極前線の経年変化を示し，また 50m. 層における 10°C. 以上域の面積と能登以北の大羽いわしの漁獲が密接な関係をもつ事を明らかにし，さらに沖合暖流と沿岸流との合流点の変化が漁況変化の重要な要因となる事を指摘した。また暖流流路・勢力の変化については日高（1950）・宮崎（1952）などの詳細な解析があるが，戦後種々の制約が設けられ，暖流全域にわたる観測も数少なく，時系的な解析は行えない。

本稿では非常に不充分であるが，綜観的解析を主体にして，1941年以降における5回の大規模な調査を比較し，対馬暖流各分枝の流路・合流域の変化および能登沖における暖流流量についてその特徴を述べる事にした(第1章　Table 1)。

II　1955年8月における対馬暖流の構造

対馬暖流の構造の詳細な論議は別に述べる事にし，ここではまず1955年8月を例にとり，力学計算によつて示される暖流構造の特徴を簡単に述べる。

fig. 1 および fig. 2 はそれぞれ 50m. 層の水温分布と 300-decibar 面（なるべく沿岸部の流路を広く知るため 300-decibar 面を基準とした）に相対した力学的高低図 dynamic topography を示している。fig. 2 より，隠岐西方から大和堆に向かい，さらに大和堆附近で能登半島に向かつて転向し，能登半島沖で再び北東へ向かつて流れる一連

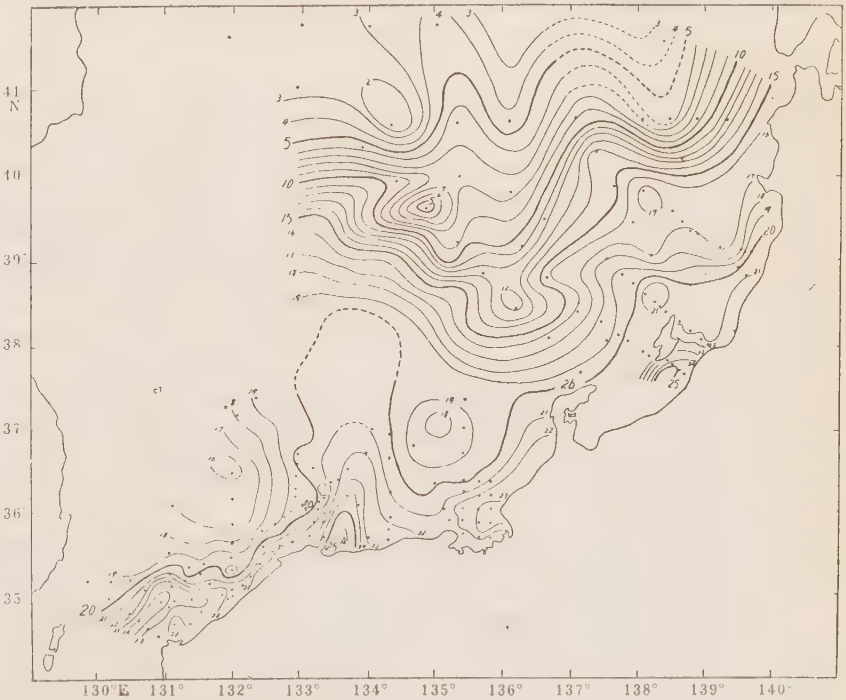


Fig. 1.　Horizontal distribution of water temperatuer (°C.) at 50-metre layer during July and August, 1955.

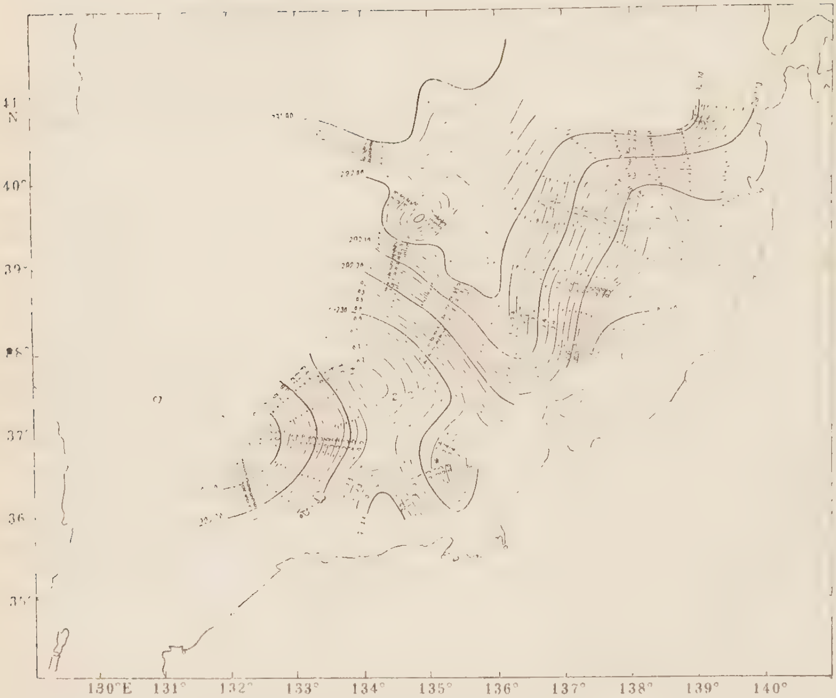


Fig. 2. Geopotential topography of the sea surface relative to the 300-decibar surface of the Japan Sea during July and August, 1955.

の強流帯の存在が認められる。この強流帯は流速0.5kt.・流幅約40浬であつて，fig. 1 では13〜17°C. の不連続線と隠岐〜大和堆間に存在する19°C. 以上の暖水域・能登〜入道埼間の17°C. 以上の暖水域によつて指示されている。一方春風堆附近には流速 0.6kt.以上・流幅20浬の狭い強流帯があり，6〜10°C. の不連続線と春風堆上の暖水域の舌状部によつて指示される。この２つの東向強流帯は対馬暖流第２・第３分枝の主流路である。

対馬暖流は対馬海峡から日本海沿岸沿いに流れる第１分枝，隠岐西方より北上し 38°N 線附近を東へ流れる中央の第２分枝，朝鮮東岸沿いに北上し 40°N 線附近で東へ転向する第３分枝，の３分枝に分れて日本海を流れるが（須田他1932・宇田1932等），これら各分枝間の特性の差は顕著なものでなく，また部分的な分岐・合流や拡散混合を伴うから，対馬海峡より離れるに従つて各分枝の分離は困難となる。しかし，ここでは水温・塩素量・溶存酸素量等の等量線の走向状態および後述のように（第３章，Ⅲ），T-Cl 関係で第２分枝主流軸の南側に見られる warm core 内の暖流中層水魂の特性が，他海域の一般的な暖流中層水魂の特性よりやや高温・高塩分であるから（T.：15.5 C. 前後，Cl：19.10‰以上），これを追跡し各分枝を定めることとする，すなわち1955年８月では，大和堆西方より能登半島沖を経て入道埼沖に向かう東行強流帯は第２分枝，また春風堆附近を通る東行強流帯は第３分枝である。

次に fig. 1・2の両図から，隠岐 NN 70浬・経ヶ岬 N 70浬・能登 NW 70浬および大和堆附近には，それぞれ左旋の渦流域（冷水域）また経が岬 N 150浬附近には右旋の渦流域(暖水域)が認められる。これ等の渦流域は比較的大規模でありまた顕著であるが，その規模は観測点間の間隔に相対し，その存在が認められない場合もある。

一般に海流は巨視的にも微視的にも渦動を伴う事は明らかであつて，海流のもつ energy を考えるにはこのような渦流によつて減ぜられるとしなければならない。海流の輸送流量の変化を取扱う場合も同様である。

いま，1955年８月の渦流域について（能登〜大和堆間の海域）その移送量を考えよう。

２点 a—b 間を通過する水の流量は

$$Q=c\int_{o}^{d}(Da-Db)\,dz$$ で表わされる

ここに，$c=\dfrac{1}{2\,\omega \sin\varphi}$

ω：地球自転の角速度

ϕ：２点の平均緯度

$(Da—Db)$ ：２点間の dynamic meter の差

d ：海深　　である。

上式より d=500m. とし，500m. を基準とした相対流量 Q' を，1955年８月における主要な断面について計算した結果は fig. 3 となる

fig. 3 より，大和堆附近の Q' 分布を見ると st. 34 を中心とする，st. 34-21・st. 34-33・および st. 34-35の各測点間を通る流量は0.53〜0.82 $10^6 m^3$./sec. であつて非常に近似している　これは fig. 2 によつても明らかなように，東行暖流の堆附近における湾曲が発達し，完全な閉じた渦動となつている事を示す。すなはち，一般に極前線以南の暖流域内において，西行流の存在は閉じた渦流と考えられる



Fig. 3. Approximate direction of the Tushima Current and volume transport in the longitudinal section off Noto Peninsula during July and August, 1955.

ある南北の断面を通過する暖流流量の実質的に輸送される量は渦流のもつ反対方向の流量を除いたものである。この実質的に輸送される流量を純東（西）行流と定義する。大和堆附近の渦流流量を st. 34-21 間の値 0.53 $10^6 m^3$./sec. とすれば，st. 34-33 間を通る流量は 0.57 $10^6 m^3$./sec. であるが実質的に東へ輸送される流量としては，その差 0.04 $10^6 m^3$./sec. であつて非常に少い。 したがつてこの東行流は暖流主流の流路を示すものでない。同様に st. 34-35間の西向流と渦流流量との差は (0.82-0.53) $10^6 m^3$./sec.=0.29 $10^6 m^3$./sec. となる。この純西行流量が，さらにその北方に位する st. 35-37 間を東行する暖流の，南側に沿つて生じた右旋の渦流の一部と考えれば，st. 35-37 間の純東行流量は (0.95—0.29) $10^6 m^3$./sec.=0.66 $10^6 m^3$./sec. である。この値は st. 35—37 のさらに東方に位置する st. 21-19 間の東行流量 0.64 $10^6 m^3$./sec. に近似している。すなはち，春風堆附近を通る暖流第３分枝の純東行輸送流量は 0.65 $10^6 m^3$./sec. と概算される。

st. 31-33 間の純東行流は 0.03 $10^6 m^3$./sec. 程度であり，東行暖流流量としても，また能登 NW の渦流流量としても非常に少いため無視してもよい。

一方 st. 31 から陸岸の間を通る流量を st. 31-29-27 間の流量に相当するとして概算すると，(1.08+5.41) $10^6 m^3$./sec.≒6.5 $10^6 m^3$./sec. となり，この量は第３分枝の純東行流量の約 7.5 倍に当る。 fig. 3 の鎖線の西方海域における暖流純東行流量から考えて，st. 31 から陸岸を通る流れは，日本沿岸沿いに東上する第１分枝・隠岐西方より北東へ進む第２分枝および朝鮮東岸沿いの第３分枝の一部が合流していると思われる。一般

に対馬暖流主流軸の南側には連続した暖水域(warm core)の帯状分布が見られ，北側には冷水域（左旋の渦動）がある。このような暖流模型を設定した場合，同じような構造をもつた2つの分枝が合流すれば，合流点附近には収斂域が形成され，大規模な暖水域すなわち右旋の渦動が生じると考えられる。fig. 1 および2より，経が岬 N 150浬附近に認められる大規模な暖水域(右旋渦動)は暖流第2分枝主流が隠岐西方より北上し，南転する屈曲部にあたつているが，これは第3分枝の一部がこの海域で第2分枝主流と合流する事を示唆するものである。この暖水域に比較すると規模は小さいが，入道埼の西方の海域には，暖水域―右旋の渦流―が常に認める事ができる。この暖水域は各図によつても明らかなように，春風堆附近を東進した第3分枝と沿岸沿いに北上した第1・第2分枝の合流海域とみなされる。このように日本海には右旋の渦流はそのほとんどが帯状または舌状の小規模な渦流の連続したもので，小規模なものが多く，大規模に発達するものは合流域のみである。これに反し一方，左旋の渦流は大規模かつ顕著である。

Ⅲ　対馬暖流主流軸と合流点の経年変化

日本海は第1近似として parallel solenoid の条件を満足している。したがつて50m.層の水温分布を採用して各年の暖流流路を概観的に推定する事ができる。

figs. 8～11 は 50m. 層水温分布（figs. 4～7）より，前述の渦動エネルギーを考慮に入れ，また東向流量最大の点を暖流主流軸とし（主要な断面をとつて各々流量計算を行なつた），それぞれの年における暖流々路を模式的に示したものである。1941年は5月～6月の状態であるが，他の各図はいずれも夏の状態である。このような季節的相違があるためこれら各年を比較する事には無理があるが，6月～8月間の日本海は比較的に静隠で擾乱が少ないと考えられるから，暖流々路に大きな変化はなくその特徴が持続するものとして取扱う。これらの各図，および fig. 4 から各年における暖流々路の特徴は次のとおりである。

1）．1941年5月～6月

日本海のほとんど全域にわたつて観測が実施されている。この年の暖流は日本沿岸を北上する第1分枝，隠岐西部より第1・第3分枝の中間をとおる第2分枝，鬱陵島東方から北東へ走り，大和堆附近から 40° N 線

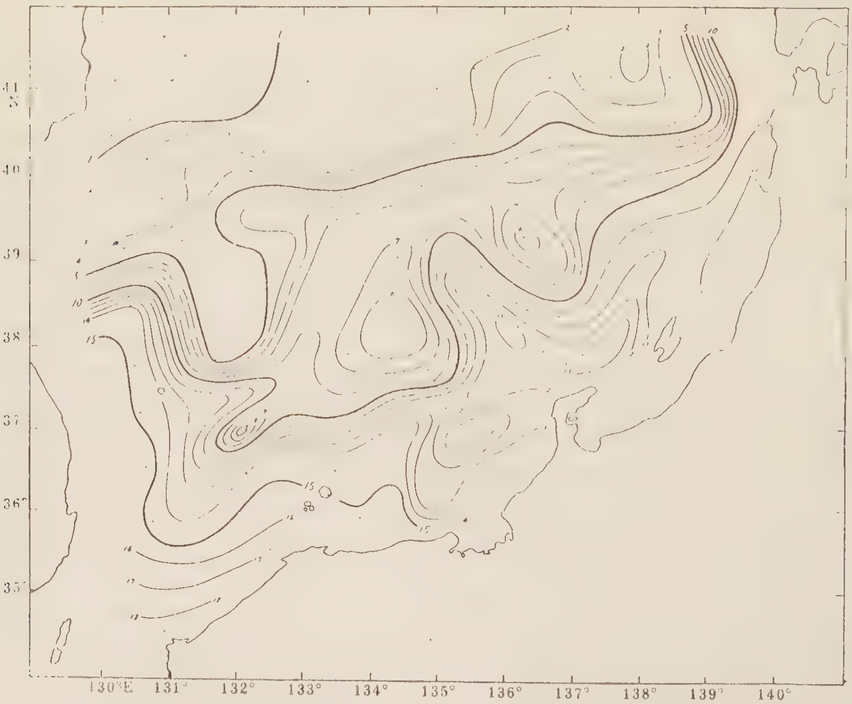


Fig. 4.　Horizontal distribution of water temperature (°C.) at 50-metre layer in May, and June 1941.

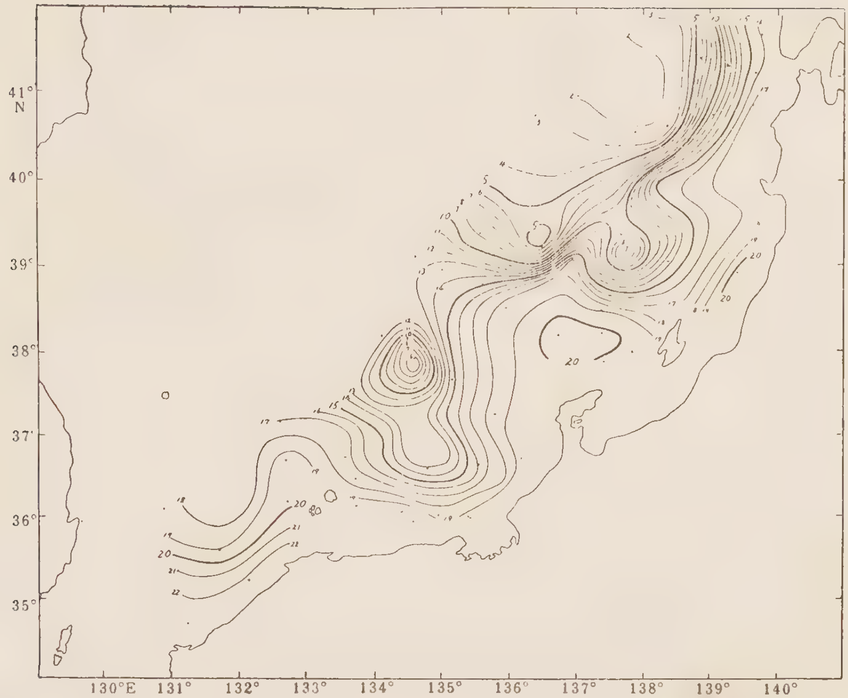


Fig. 5. Horizontal distribution of water temperature (°C.) at 50-metre layer during August and September, 1946.



Fig. 6. Horizontal distribution of water temperature (°C.) at 50-metre layer in August, 1948.

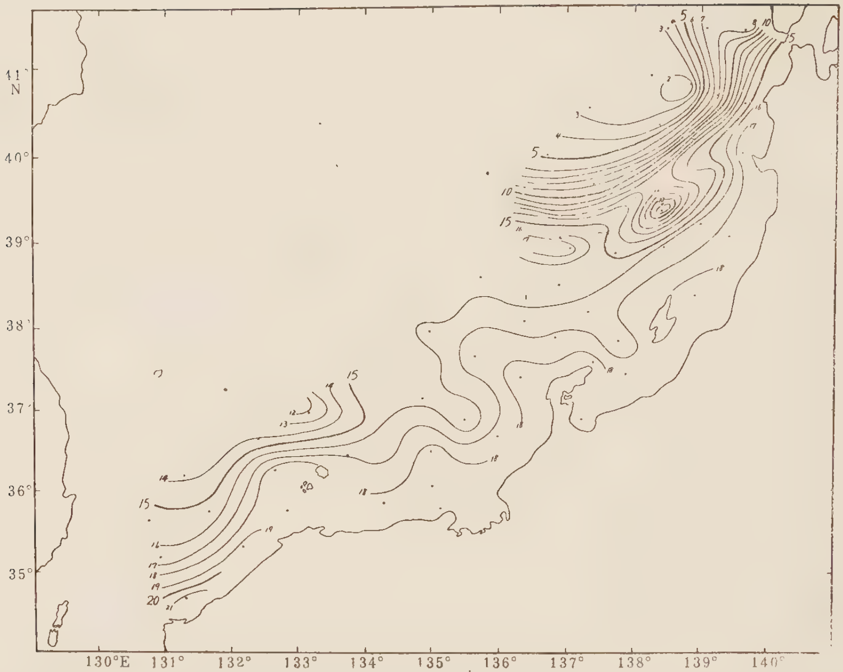


Fig. 7. Horizontal distribution of water temperature (°C.) at 50-metre layer in August, 1949.



Fig. 8. Schematic representation of ocean currents in the Sea of Japan in May, 1941. The low temperature regions are shaded (L. T. R. : Low Temperature Region).

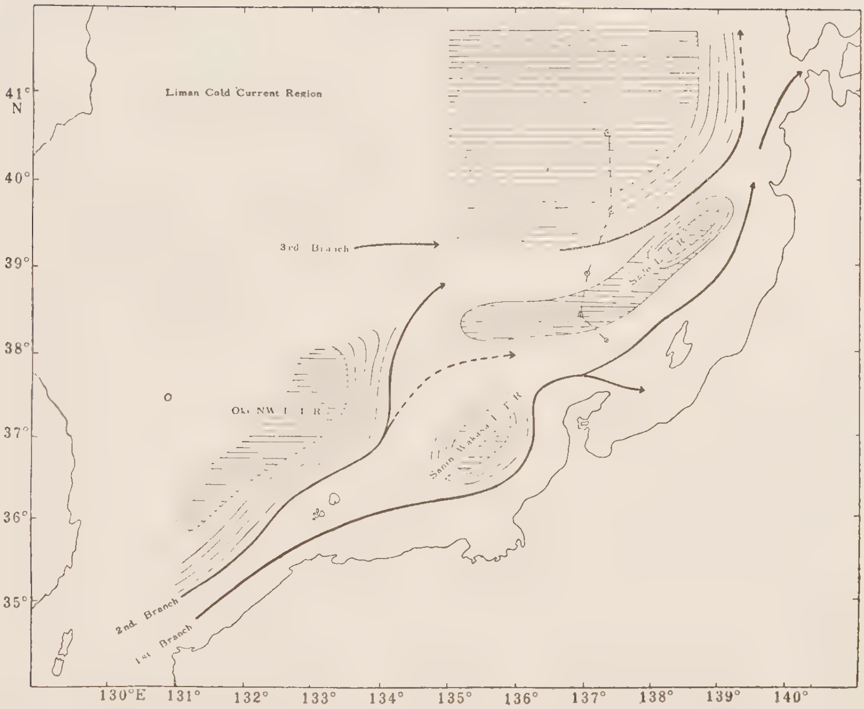


Fig. 9. Schematic representation of ocean currents in the Sea of Japan during August and September, 1946. The low temperature regions are shaded.



Fig. 10. Schematic representation of ocean currents in the Sea of Japan during July and September, 1948. The low temperature regions are shaded.



Fig. 11. Schematic representation of ocean currents in the Sea of Japan in August, 1949. The low temperature regions are shaded.

に沿つて東流する第3分枝の各分枝の主流路は，各分枝間の冷水域と主流軸の南側における帯状高温域の存在によつて明瞭にわかち得る。第1分枝と第2分枝は能登半島沖で合流している。この合流域には高温域が北西にのびている事から第3分枝の一部も北西方向から合流しているものと考えられる。第3分枝は 136°〜137°E 間で北方へ一分派を出しているが，その主流は入道埼西方で第1・第2分枝と合流している。すなわち主合流域は入道埼西方となる。

2）. 1946年8月〜9月

第2分枝の一部は隠岐島西方より北流し，大和堆西方の沖合で第3分枝と合流していると考えられる。しかし，その主流は第1分枝と同じく日本の沿岸沿いに北上し，能登半島西方で北東へ進む。第3分枝は 39° N 線を東進し，能登半島の北方沖合で第1・第2分枝と合流している。この年における特徴は第3分枝が著しく南へ偏つて流れている事と第1・第2分枝が能登以北で沖合に離れる事である。

3）. 1948年7月〜9月

1941年と同じく各分枝はその間にある冷水域群によつて比較的明瞭にわかち得る。すなわち第2分枝は隠岐島北側より能登半島に向かい東進し，第3分枝は 40° N 線を東進する。第1・第2分枝の合流点は能登半島高温域であらわされ，さらに入道埼西方で第1・第2・第3分枝の主流が合流する。

4）. 1949年8月

第2分枝は隠岐北方で北流し大和堆附近で第3分枝と合流する。第3分枝は1946年と同じくやや南偏して 39° N 線を東進する。能登沖の第2・第3分枝と沿岸を北上する第1分枝とは入道埼西方で合流し，その間には帯状冷水域が存在する。

Ⅳ 能登半島N断面における暖流々量の経年変動

次に能登半島北方における暖流勢力を考察しよう。fig. 3 および fig. 4—7 の各図中の濃線で示した断面に

ついてその断面を通過する流量を既記の式 $Q=c\int_{o}^{d}(Da-Db)\,dz$ によつて 500—decibar 面を基準として計算した結果は，table 1 に示される。これらの断面はほぼ流軸に直角となるように，また 38° N 線から第3分枝北方の冷水域（リマン寒流域水）に達するように設定されている。したがつてこの断面を通過する流量は沖合暖流の増減を意味する。table 1 から，1948年は東行流量の最大を示し，その大部分は 39°〜40° N 間（st. 69—70）間をとおつている。この年はまた西行流量も各年中の最高値を示し，st. 56〜69 の間をその大部分が通過し，純東行流としては各年に比較し中位にある。しかしこの西行強流の存在は，前に述べた1955年8月の大和堆北部の西行流量に比べても著しく大きく，かつこのような大きな反時計廻りの渦流（冷水域）は fig. 6 に認められない事から，この西行流は能登半島で北に向かい，st. 69—80 間を流れる東行暖流に連なるものと考えられる。したがつて1948年の純東行流としてはこの西行流を除いた 10.11 10^6m^3./sec. と概算され，東へ輸送される暖流々量は各年を通じて最大である。また1941年と1955年は東行暖流の流量はいずれも著しく小さい。

Table 1 Yearly fluctuations in the volume transport in the longitudinal section off Noto Peninsula between lat. 38° N. and the Liman region.

Transport (10^6m^3./sec.)	1941	1946	1948	1949	1955
Eastward	3.23	8.36	10.11	6.12	2.69
Westward	1.56	1.10	5.27	2.53	0.88
Difference	1.67	7.26	4.84	3.59	1.81

能登半島北方の 38° N 線と極前線間を流れる暖流々量と，暖流主流分枝の流路は，前述の各年における特徴から密接な関係がみられる。暖流々量の少ない1941年と1955年の両年は相似した等量線の走向を示し，その両年の共通の特徴は能登半島の北西方向に帯状または大規模な暖水域（warm core）が明瞭に存在する事，及びこの暖水域の存在から 40° N 線附近を東進する暖流第3分枝の一部が能登半島に接岸し，第1・第2分枝と合流すると考えられる事の2点である。また合流後その主流は入道埼に向かつて直行し，このため佐渡〜山形附近の沿岸は全般的にやや低温の地帯となる。

一方暖流々量の多い1948年および中位の流量をもつ1946年では，能登半島西部より暖流第1分枝が北東へ向かい，陸岸から離れて流れているが，佐渡北方で東方あるいは東南へ転向し，入道埼〜新潟県の海域では陸岸に近寄る傾向がある。この場合入道埼〜新潟の沿岸部は他区域より高温となる。

また1949年においては流量は第3位でやや少ない。この年の特徴は，能登半島西北西方向に暖水域があるが，周縁地域との水温傾度は比較的小さい。この暖水域は暖流第2分枝との合流部であつて，暖流第3分枝との合流点とは考えられない。したがつて流量の示すごとく，むしろ流量の少ない年に類似している。

V 能登沖における暖流々量と日本海北区の大羽いわし漁況との関係

能登半島沖断面をとおつて東へ流れる暖流々量の変化は，その断面から以東の海況に大きく影響し，その結果沿岸漁況に対しても著しい要因となり得る事は容易に推察できる。各年の農林統計から日本海北区における大羽いわし漁況について考えよう。漁獲量の変化は海況の変化にのみ影響されているのではなく，魚自体のもつ再生産力あるいは人為的な漁獲努力の変化等の要因の組合わされたものである。したがつてこれらの影響を除くため，生物的要因・人為的要因・長期の海況変動等が日本海北区全域に一様に影響するものと考えて，地域的相互，すなわちここでは新潟，山形，秋田3県の大羽いわしの合計漁獲高と，石川県の大羽漁獲高の比を求め，これと純東行暖流々量の関係をみる事にする（fig. 12）。fig. 12 では少数の資料であるため正確な関係は見出されないが，1941年の示す値は6月の流量であつて，夏の流量に比して小さい事が考えられるからこれを除けば，概観的に逆相関であつて，相当に相関係数の高い事が指摘できる。またこの暖流々量は 38° N 線以北の海面について計算してあるから，沖合暖流の増大している時には，新潟〜秋田間の漁獲が減少する事を意味する。

VI むすび

本稿では1955年を中心として対馬暖流の変化について述べてあるが，資料不足のため時系的な解析は全くで

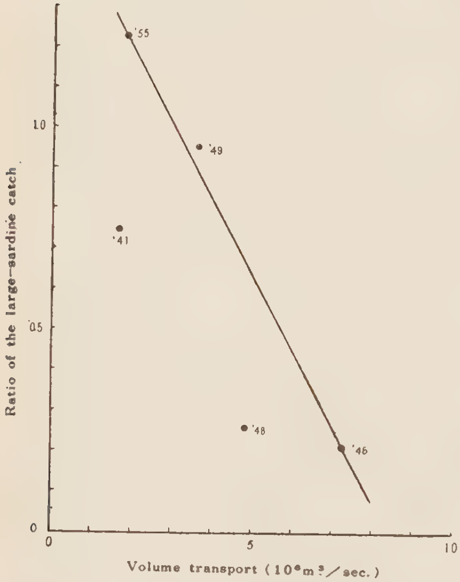


Fig. 12. Relation between the volume transport and the ratio of the large-sardine catch in Ishikawa Pref. to the total catch, including Niigata, Yamagata, and Akita Prefs.. The Arabic numerals designate the years.

きず，むしろ対馬暖流の定性的な特徴の一部に触れたにすぎない。しかしこのような特徴からも，漁況と密接な関係がある事がわかつた。また例えば1948年春夏におけるトビウオ，ソウダカツオの非常な豊漁は全く暖流勢力に起因するものと考えられ，また1956年春季の能登以北の大羽いわしの漁況に大きな影響をおよぼした沖合暖流の強流化に伴う沿岸の低温現象は，第2分枝の外側低温帯が沿岸寄りに生じたものと理解される。また，各年の暖流の流路と流量の特徴は次のとおり類別される。

〔A〕 沖合暖流々量の多い年———1948年夏，1941年春

特徴

1). 暖流第1，第2，第3の各分枝の流路が明瞭にわかち得る。

2). 第3分枝流路は 40° N 線附近を東進する。

3). 各分枝合流点は入道埼沿岸となる。

〔B〕 沖合暖流々量の少ない年———1955年，1946年，1949年

特徴

1). 第3分枝流量は非常に少ない。

2). 第3分枝流路は南偏する。

3). 各分枝流点は1941年，1948年に比べると，さらに西へ移る。

第3章　日本海における主要冷水域の海洋学的考察

Chapter 3　A Study on the Main "Low Temperature Regions" in the Japan Sea.

I　は　し　が　き

沿岸の漁況変動や漁場の変化の要因として海洋の質量分布，プランクトンの分布等の変化については既に多くの研究が行われている。これ等の研究においてもまた実際の漁場探索等においても，沖合冷水域の存在とその存在による種々の影響は古くから注目されている事象である。すなわち，1934年頃より1945年頃まで大平洋の紀州沖に大冷水域が出現し，沿岸漁況に大きな影響を与え，また California 沖におけるいわし不漁の調査においてもその沿岸に出現する渦流（冷・暖水域）が一要因となつていることは衆知のとおりである。

著者等（1953）は佐渡北方に発達する冷水域の性状を明らかにし，下村（1954）は能登以北の春季における大羽いわし漁況が佐渡冷水域の消長によつて変化する事を示した。しかしながらこのような冷水域の変化等についてはまだほとんど明らかでなく，特に日本海の各処に生ずる冷水域に関する知識はそれ自体のまとまつたものはなく，観測報告等にその片鱗を見出し得るに過ぎない。これは，冷水域の実体が反時計廻りの渦流であつて，このような渦流は海流のように巨視的にほとんど定常状態を示すものでなく，絶えず生成消滅し，かつ調査の規模や期間も微細なものを必要とする事などによつて，従来の観測ではその解明が困難であつたと云う理由が挙げられ，特に漁業の最盛期にあたる春季は対流混合期にあたり，上層水はほとんど均一であり，また変化も烈しいところに困難な問題があつたと云える。そしてまた冷水域の本質を見るためには，当然渦動発生の基本となる暖流の構造，さらには海流の原動力となる卓越風による応力や，海流の熱力学的なエネルギーについても解明しなければならない問題が含まれている。このような多くの問題はそのいずれも全く未知の分野と云つてよい。

1953年以降行われてきた**対馬暖流開発調査**は距岸約 100浬以内の海域に密な観測網を設定し，毎月1回一斉観測式の調査を行つており，資料も大分集積された。特に能登以北の北部日本海では，春の大羽イワシの漁況予報の必要上，春季は約15日間隔で観測が石川〜青森の6県水試及び日水研の協同下に行われ，冷水域の解明が一応可能となつてきた。また著者らは昭和30年8月以来数次にわたつて，さらに沖合の沿海州沿岸に至る大規模な観測を行つており，海上保安庁によつても行われている。これ等の数次の大規模な観測によつて沖合冷水域相互の関係が明瞭になつてきた。

本稿では，日本海冷水域の概念について述べ，明確な出現機構を有する例として**大和堆冷水域**を，また漁況変動に直接影響する例として**山陰若狭冷水域**を挙げて，その細部にわたる解析を行つた。その他の冷水域についてはその変化の大勢を概観するに止め，詳細な論議は後日順次発表する予定である。

II　日本海の代表的冷水域とその特性

まず後述の冷水域の変化やその機構について述べる前に，著者等の行つた1955年夏（fig. 1）の資料を中心として日本海冷水域のもつ概念を明らかにしよう。

1　1955年 8 月における代表的冷水域

夏季においては海洋の諸性質の垂直分布は非常に安定度高く，水平的分布においても各地点のもつ特性上の差異は，他の季節におけるより顕著に現われる。したがつて夏季における冷水域は容易に判別することができる。fig. 1 は1955年8月の 50m. 層水温分布であるが，この図から顕著な冷水域として，まず隠岐島NW 70浬附近に中心示度9°C.以下の冷水域が認められ（**隠岐NW冷水域**），この附近からさらに山口県沖30浬附近まで幾つかの中心をもつた帯状に連つた冷水域が見られる（**島根冷水域**）。後者の帯状冷水域は他の層では不明瞭ながら切離（cut off）された部分があり，非常に不安定な冷水域である事が認められる。そしてこの地域の冷水域は対馬暖流々路を日本沿岸沿いに進む第1・第2分枝と東鮮暖流（第3分枝）を分つ非常に重要な意義を有する事は容易に想像される。

また経ケ岬N70浬附近には中心示度 18°C. の冷水域があり，この冷水域は後述のごとく，**山陰若狭冷水域帯**

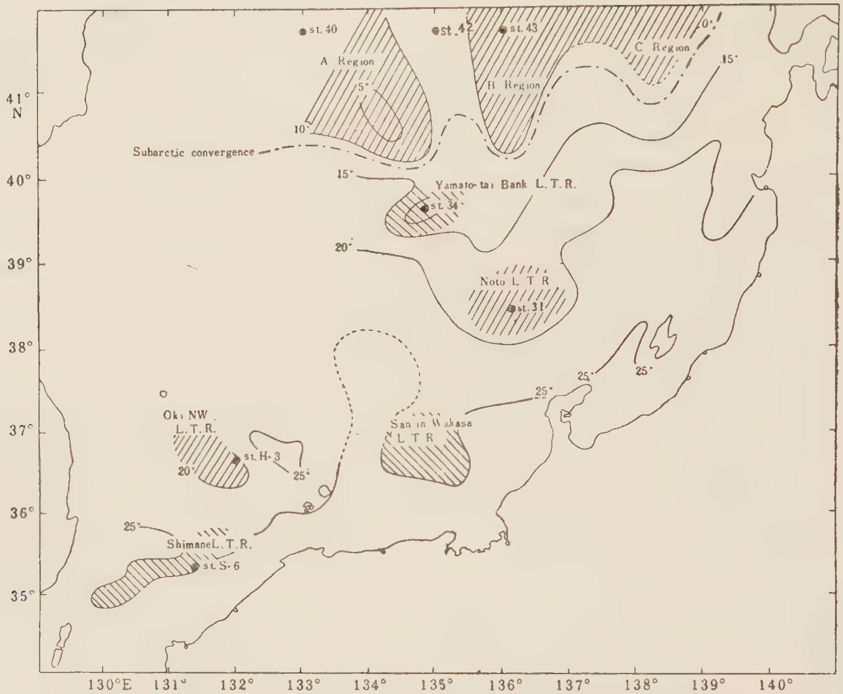


Fig. 1　Low temperature regions shown by isothermal lines at 50-metre layer during July and August, 1955. (L. T. R. designates the Low Temperature Region)

として発達し，比較的小規模ながらその渦動エネルギーは大きく，沿岸漁況に非常な影響を与えるものである。この冷水域の存在はまた沿岸を東上する第1分枝と隠岐西方より第1分枝と分離した第2分枝の主流路を分つものである。能登NW70浬附近には中心示度 12°C. 以下の冷水域が見られるが（**能登冷水域**）この冷水域は非常に小規模であり，水温傾度は小さい（下村，宮田 1956)。この冷水域は時々発達する事があり，主として沿岸を流れる第1分枝と隠岐北方を通る第2分枝との合流域を決定するものとして考えられる。

大和堆附近には中心示度 5°C. 以下の低冷な冷水域が存在している（**大和堆冷水域**)。この冷水域の存在は既に古くから知られ，朝鮮沿岸を北上した暖流第3分枝が Lat.40°N 附近において東へ転向し，この堆附近の冷水域によつて更に南西へ偏向すると考えられている（宇田 1932)。fig. 1 においてはこの冷水域は第3分枝一部の南東への偏向と，春風堆附近を東進する第3分枝主流の流路を明瞭にしている。

寒流系水と暖流系水は 40°N 線附近にある 5°C. 線を中心とした不連続面（リマン前線 Liman Front）によつて分たれ，このリマン前線以北の海域は3つの中心をもつ冷水域となつて表示される。この海域ではすべて寒流系水であるが，西方から**北方A冷水域・B冷水域・C冷水域**と呼ぶと，後述の如く **A 冷水域**と，**B・C 冷水域**の Cl の分布において顕著な差異が認められる。すなわち，**A 冷水域**においてやや低鹹な特徴をもつ。またこれらの極前線以北の冷水域の内，**C冷水域**は夏季には**B冷水域**と明瞭に切離され，春風堆附近から北海道神威岬に向う暖流第3分枝の流路が認められる事があり（下村，宮田 1956)，暖流系水の影響を受けることが最も大きいが，この冷水域に関しては後日さらに論議を重ねたい。さらに fig. 1 には認められないが，各年の状況から佐渡N 70浬附近には冷水部がしばしば出現するが（**佐渡冷水域**)，この冷水域は後述の如く非常に変化に富み，漁業上にもその変化は重要なものである。

以上の代表的冷水域は fig. 1 に模式的に示される。

2　夏季における T—Cl 特性

日本海の水塊分析は多くの人によつて詳しく行われている。ここではその代表的水塊については赤川 (1954) に従つて分類し，主として寒暖両水系の中間型を示す冷水域の水塊組成について述べよう。

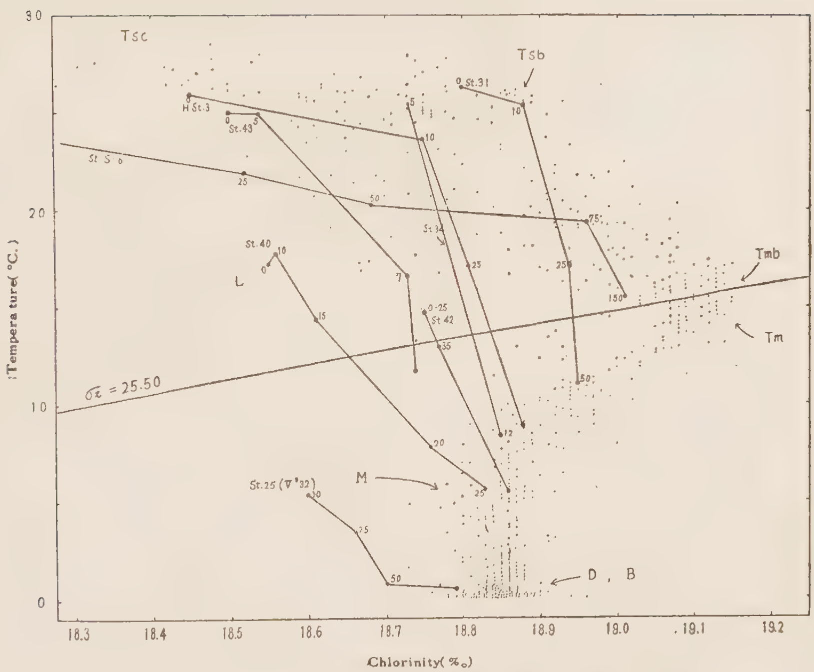


Fig. 2 Temperature-chlorinity relations for representive stations within the low temperature regions and water masses in the of Japan Sea during July and August, 1955. Depths in metre are entered along the curves. Locations of stations are shown in fig. 1. Station 25 (the Sôyô-maru) are located at lat. 41° 06′ N, long. 130° 09′ E.

The warm Tsushima Current
Tsc: Coastal surface water
Tsb: Oceanic surface water
The cold Liman Current
L : Surface water
Characteristic water (Nihonkai koyû-suikai).
M : Intermediate water
D : Deep water
B : Bottom water

Table 1 Character of the principal water masses in the Japan Sea (in August, 1955).

水系	水塊	T (°C.)	Cl (‰)
対馬暖流系	沿岸暖流 表層水 (Tsc)	24—28	18.50 以下
	沖合暖流 表層水 (Tsb)	24—28	18.50 以上
	暖流 中層水 (Tm)	15—16	19.05—19.20
リマン寒流系	寒流 表層水 (L)	15—18	18.50—18.80
日本海固有水	中間水 (M)	5 内外	18.70—18.83
	深層水 (D)	1 内外	18.86 内外
	底層水 (B)	0.5以下	18.79—18.89

fig. 2 は1955年8月中行われた日本海の全観測の T—Cl 関係と, fig. 1 に示される各冷水域の代表点におけ

る T—Cl 曲線を表示している。fig. 2から既に知られている如く日本海における6つの代表的な水塊が認められる。これらの水塊の示す特性は table. 1 のとおりである。table. 1 において暖流系表層水は，沿岸流の低鹹な水塊と沖合流（第2・第3分枝）の，より高鹹な水塊とに区別されるが，その境界は明瞭でない。日本海の冷水域内の T—Cl 曲線はほとんど後者の沖合流表層水塊の存在を示す。

暖流系中層水塊は Cl 19.00‰ 以上の日本海の最も高鹹な特性を有し，この水塊が沖縄列島において黒潮から分枝して日本海に流入したものであることは明らかである。fig. 2 からこの暖流系中層水塊をさらに詳細に見ると，リマン前線以南のほとんど全海域の T—Cl 曲線は最高塩素量として 19.10‰の範囲に入つているのであるが，第2分枝主流軸と見なされる warm core では Cl 19.10〜19.20‰ のやや高い塩素量を示し，他分枝の warm core ではこのような高塩素量は見られない。いまこの両者を 19.10‰ で分ければ，その中心はそれぞれ T=15.0°C.，Cl=19.07‰ および T=15.5°C.，Cl=19.12‰ の特性を持つ。そして後者の高鹹な中層水塊は入道埼附近の st.11 にまで追跡し得る。このような高鹹水塊の存在は，それが第2分枝の warm core に属する事と，日本海の暖流系中層水塊の一般的な特性はやや低い温度・塩分の特性をもち，しかもこの両者の中心は σ_t =25.50 面上にあつて容易に変換し得る事から，対馬暖流の第2分枝の構造が他分枝と異つて，黒潮から分離した暖流のもつ特性を比較的失わない特徴をもつていると考えられる。

寒流系水はst.40，st.41，st.42 の示すとおりリマン前線（極前線）以北の海域で代表される。fig. 2において その表層水は温度・塩分共に暖流系表層水に比して，著しく低温・低鹹の特性を有しはつきりと判別される。そしてその寒流系表層水塊は，その代表点における T—Cl 特性に見られるとおり，st.40 と st.42 の間には顕著な差異がある。すなわち，st.42 では st.40 より著しく低温・低鹹である。この差異は st.40 における T—Cl 特性は南部沿海州の沿岸を南下しているリマン寒流（fig. 3には 1932年6月蒼鷹丸観測点 st.25 の T—Cl 曲線が記入してある）の非常に低鹹な特性によつてその影響下にある事が推定されるのに反し，一方 st.42 では沿海州北部における結氷により生成された高鹹水が残存しているものと考えられる。

次に中間水塊および底・深層水塊であるが，これ等の水塊は均質であつて，それが寒流域内にあるか，暖流域内にあるかによる差はほとんどなく，日本海全域に普遍的に存在する。この事は寒暖両水系を区別する際には，中間水塊に達するまでの上層における水塊だけを考えればよい事を意味する。冷水域について云えば，それが暖水域と相対的な関係にあるから，その特性も中間水以浅において顕著な差を有することになる。

fig. 2 は各冷水域の代表的な T—Cl 曲線を図示しているが，これらの冷水域の T—Cl曲線は中間水塊以浅の上層において，前述の代表的水塊を通らず，寒暖両水系の中間に特性づけられる。換言すれば冷水域内の T—Cl 曲線は暖流系中層水塊の著しく変質したものを有するか，または全く欠除している事が非常に大きなと特徴なつている。fig. 2 に示されている如く σ_t =25.50 面を考えるならば，暖流系中層水塊と寒流系表層水塊はだいたいこの面にある。したがつていま fig. 1 に示される冷水域の代表点の T—Cl 曲線と，この面との交点を採用すると，各冷水域間の特性は**島根冷水域**（st. S－6）**山陰若狭冷水域・能登冷水域**（st.31）・**隠岐NW冷水域**（st. H3）・**大和堆冷水域**(st. 34）の順に暖流中層水塊の変性が見られる。ここで**大和堆冷水域**は極前線近くに存在し，その特性も寒流水系に近い事は当然であるが，南部の**隠岐NW冷水域**が**大和堆冷水域**の如き寒流系水に最も近い特性を有する事は，この水域において非常に激しい湧昇流の存在を意味していると考えられる。

また**島根冷水域**は暖流中層水塊をほとんど変質しないが，その表層水塊の特性は温度の低い事を示し，この冷水域の構造が他の冷水域の構造と異つている事を暗示している。

3 春季における冷水域の特性

fig. 3A には 1955年3月下旬と1956年4月上旬，fig. 3B には 1955年5月上旬と6月上旬における数測点の T—Cl 曲線をそれぞれ示している。この両図から3〜4月においては，水温 10°C. 前後・塩素量 18.80〜18.90‰の上層水塊と水温1°C.前後・塩素量 18.85‰の深層水塊の2つの水塊よりなり，約 100m. より浅い部分にある上層水はほとんど一点に集中するか，または極めて不規則な層重状態を示し，対流混合の烈しい事を示す（註：fig.3Aの1955年における各曲線は，1956年におけるそれぞれの全般的に塩素量が 0.1‰程度たかめになつている。夏の T—Cl 関係の中間水塊以下の特性があまり変化しないと考えられることから，1956年のデータを附

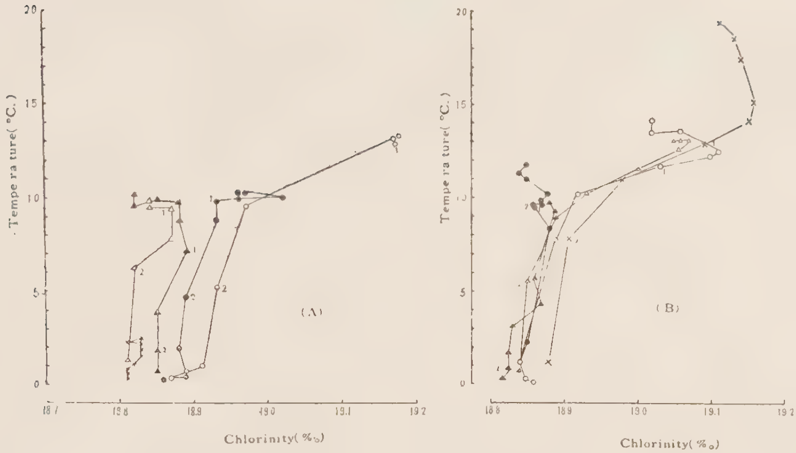


Fig. 3 Temperature-chlorinity relations (A) in March, April and (B) in May and June, 1955.

○	st. 16	Lat. 36°20′N, long. 134°00′E March 30, 1955	○	st. 12	Lat. 37°00′N, long. 134°00′E May 6, 1955
•	st. 17	Lat. 37°00′N, long. 134°00′E March 31, 1955	•	st. 13	Lat. 37°40′N, long. 134°00′E May 6, 1955
△	st. 20	Lat. 38°49′N, long. 138°45′E April 5, 1956	△	st. 14	Lat. 38°20′N, long. 134°00′E May 7, 1955
▲	st. 17	Lat. 38°50′N, long. 135°53′E April 4, 1956	▲	st. 15	Lat. 39°00′N, long. 134°00′E May 7, 1955
×	st. 5	Lat. 41°14′N, long. 135°55′E April 3, 1956	×	st. 7	Lat. 35°42′N, long. 133°58′E June 6, 1955 (Tottori P.F.E.S.)

記し，水塊の特性値は 1956年のものを選んだ)。st. 5 は寒流系水域の状態を示すものであつて，表面においてすでに深層水塊の特性を示している。また st.16 は日本海の南部の沿岸ちかくの測点であつて，ここでは次に述べる５月上旬と同じように，暖流系中層水塊にちかい特性をもつた上層水塊を有している。

５月には３月上旬の上層水と同じく 100m. 以浅はほとんど一点に集中し，不規則な層重を示すが，陸岸ちかくの測点では高温高鹹な特性となり，暖流中層水塊の影響が明瞭に認められる。さらに６月上旬には明らかな暖流中層水塊の特性を示すようになる。そしてこの時期において成層状態となつている。すなわち T—Cl 曲線の変化より，冬季は海面の過冷却のため垂直対流が盛んであり，海水は次第に上部から均質化される。そして春から夏にかけて徐々に安定した成層を形成するのであるが，３〜５月はまだ充分に成層状態は発達せず６月に安定な成層になると言える。このような時期においては，冷水域の本質が渦流であるためその渦動は擾乱によつて直ちに著しく変化し，夏季にみられるような安定した大規模な渦流は形成し難い事が容易に考えられる。したがつて12月〜５月，特に２〜３月の上層水塊内では水温・塩分等の分布は水平的にも垂直的にも大きな傾度がないため冷水域の設定はできない。しかし深層水塊と上層水塊との間においては塩分はほとんど変化しないが，水温の著しい躍層があり，この躍層附近（200m. 層）の水温の地域間の差異は，最も大きい。したがつて 200. 層における水温分布によつて春季の冷水域を定めると，比較的安定した現象として取扱う事ができる。しかも成層状態にある夏季の冷水域についても適用し得る。何故ならば，夏季における第２不連続面に相当する躍層の深さを決定する事ができ，それは parallel solenoid 場の理論から，近似的にその上層の密度の積分値すなわち海面の高低を表示するものとして良いからである。

このようにすれば春から夏への冷水域の変動が容易に追跡できる。したがつて本稿では，春季における季節変化を述べるに際して，冷水域を第２不連続面の高低として定義することとする。

4　冷水域変動の概観

太平洋側に存在する紀州沖合冷水域は年により大きな変動を示し，時には全く出現しない　日本海の各所に

存在する冷水域も非常に変化にとみ，佐藤等（1950）は対馬暖流第2分枝流路の変化の重要性を示唆しているが，この事はまた日本海冷水域の年変化を意味するものである。table 2 は，リマン前線以南の対馬暖流域における主要な冷水域の変化を見るため，緯経度1度区劃の代表的な海域を選定し，1953年から1955年までの各月の冷水域の出現状態を 50m. と 200m. 層の水温水平分布から求めたものである（但し，冬季の対流混合の盛んな時期を除く）。まえに農林省水産試験場・水路部等による過去における大規模な観測の50m. 層水温分布に認められる冷水域の所在を示した（第2章 fig. 4 —11，p.p.78-82）。これらの図表に示される変化またはその特性の差から，日本海の冷水域は次のとおり分類できる。

Table 2 Characteristics of the low temperature region for representative areas.

海域	冷水域	年＼月	3	4	5	6	7	8	9	10	11	変動の特性
39° — 40°N 134.5° — 135°E	大和堆冷水域	1953	—	—	—	○	○	—	—	—	—	堆附近に定常的に存在する。
		1954	—	—	—	—	○	○	—	—	—	
		1955	—	—	—	—	—	○	—	—	—	
35.5° — 36.5°N 131.5° — 132.5°E	島根冷水域	1953	×	—	×	×	×	—	×	○	—	年変化月変化が烈しい。
		1954	○	×	○	×	×	○	○	—	—	
		1955	○	—	×	○	○	○	○	—	—	
36° — 37°N 134° — 135°E	山陰若狭冷水域	1953	○	○	○	○	○	—	○	○	—	定常的に認められる。
		1954	○	○	○	○	○	○	○	○	○	
		1955	—	○	○	○	○	○	○	○	—	
37.5° — 38.5°N 135.5° — 136.5°E	能登冷水域	1953	×	○	—	○	×	—	—	×	—	年変化が大きいが比較的存続する。
		1954	×	○	×	×	×	○	×	○	×	
		1955	○	○	○	—	○	○	○	○	—	
39° — 40°N 138° — 139°E	佐渡冷水域	1953	○	○	○	○	—	—	—	○	—	年変化が大きい。
		1954	○	○	○	○	○	○	○	○	—	
		1955	○	×	○	×	—	×	×	×	—	

(1) 経年的にも季節的にも定常的に見出されるもの。

大和堆冷水域・隠岐NW冷水域・山陰若狭冷冷水域

(2) 経年的季節的変化の激しいもの。

島根冷水域・佐渡冷水域

(3) 経年的変化は激しいが，比較的永続するもの。

能登冷水域・山形沿岸冷水域

(4) その特性が経年的にも変化するもの。

佐渡冷水域

(5) 純寒流系のもの。

"A"冷水域・"B"冷水域・"C"冷水域

Ⅲ　冷水域の変動とその機構

1　地形性定常冷水域

日本海の冷水域の各年の変化を検討し，定常的なものと，非定常的な性格のものとがある事を明らかにした。これらの冷水域の機構については定常的な冷水域としたものであつても その実体が渦流であるから詳細な調査では相当な変化があり，単純な要因のみでその変化をみる事はできない。各年に突然出現するものや，位置や規模が絶えず変化するものについては，さらに複雑な要素が含まれる事は当然である。しかし，経年的にも季

節的にも安定していると思われる冷水域については，海底地形による要素が大きいと考えられ，このような形の理論は既に Ekman (1932) 等によつて論議されている。

日本海において，明らかに海底地形によると考えられる冷水域は，**大和堆冷水域**であり，その存在は古くから認められている。

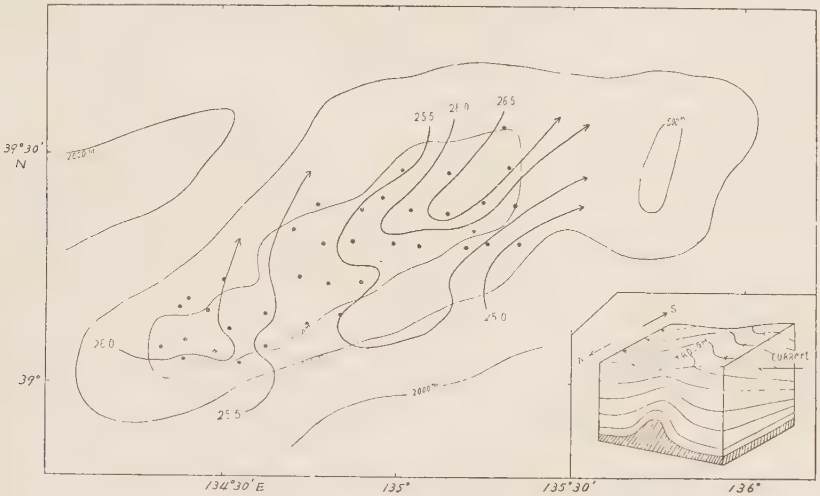


Fig. 4 Horizontal distribution of density in the Yamato-tai bank in August, 1947. Inset map shows schematic representation of current when passing a ridge (after Sverdrup).

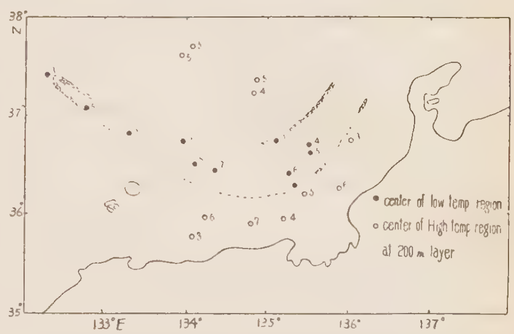


Fig. 5 Monthly changes of center of the low temperature regions and high temperature regions at 200-metre layer.

(the Arabic numerals designate the months.)

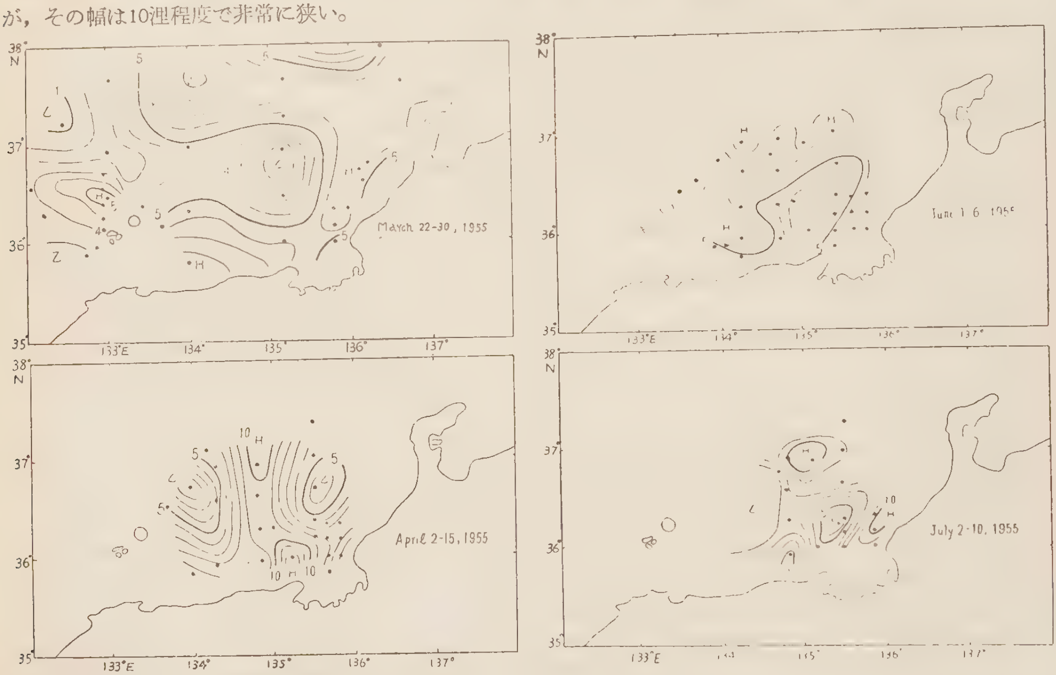
1947年8月俊鶻丸は大和堆上の精密観測（50測点）を実施したが，fig. 4 はその25m.層の等σ_t線水平分布と大和堆の等深線である。等密度線上の矢印は高密度水を左手においた海流の方向を示す。fig. 4 より堆の西端に$\sigma_t = 26.00$以上の高密度水，またその東端にも$\sigma_t = 26.50$以上のさらに高い密度をもつ水塊がある。堆中央部は$\sigma_t - 25.50$以下の低密度水によつて占められている。これらの密度分布にみられる様相は Ekman の理論とよく一致している（Sverdrup et al, 1952）。すなわち，この密度分布は等圧面の昇降を意味し，北半球では堆の中央部で等圧面降下による傾斜流を生じ，堆え向かつた海流は堆前面で右側に屈曲する（fig. 4 内挿図）。fig. 4 では堆中央部で等圧面が上昇し，理論と異なるが，大和堆の北側にある春風堆や，堆に向かう海流の流向などの影響と思われる。このような地形性過動の例を他に求むれば，**山陰若狭冷水域**は，多分に隠岐海嶺の影響が考えられ，**能登冷水域・佐渡冷水域**も多少地形的な影響を受けていると考えられる。

2 山陰・若狭冷水域

この冷水域の存在はそれが沿岸近くで発達し，非常に顕著な冷水域であつてその変化も激しい性質をもつため，沿岸漁況に大きな影響を与える事は明らかである。例えば山陰の6月頃盛漁期であるスルメイカの漁況から，またサバ漁場変化にその顕著な影響をみる事ができる。

1）経年変化に見られる特徴

この冷水域は大和堆冷水域・隠岐 NW 冷水域と同じく毎年定常的に見られる事は既に述べたが，さらに各年の主要な特徴を検討しよう。1946年・1949年・1955年は若狭湾 N60—90 浬附近に一つの大きな渦流があるが，他の年では隠岐島東方および能登半島の西側に2つの冷水域となつて出現している。この水域はいずれも周縁温度傾度が大きく，その規模は一つの渦動のとき直径60浬，2個の渦動のとき直径40浬の程度であり，その中心（kinematic center）の水温示度はその位置が隠岐島の近くにみられる時最も低く，能登半島に近ずく程高くなつている。2個の渦動の場合その2つの冷水域の間に帯状の暖水部があつて明瞭に cut off されるが，その幅は10浬程度で非常に狭い。



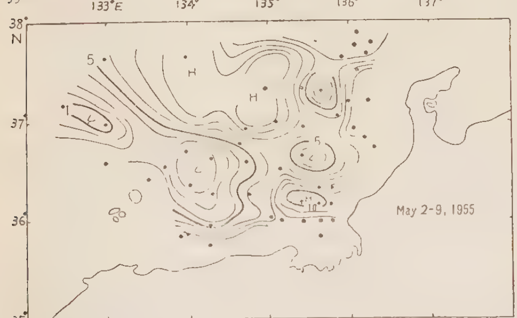


Fig. 6 Horizontal distribution of water temperature (°C.) at 200-metre layer.

この冷水域とさらに沖合の能登冷水域とは，第2分枝主流軸である帯状又は東へ向いた舌状の暖水部によつて cut off されている事は1941年の観測に明らかである。他の年では観測点間の距離が大きいため不明瞭ではあるが，高温域の舌状部のつながりからそのことが認められる。これらの冷水域は隠岐島〜能登半島を結ぶ線上にその中心位置が存在し，南北の振動が小さい（fig. 5）。この事は後述の短期変動にみられるように，中心位置が移動する際一つの低圧帯を形づくる事になる。すなわち，ここで述べる山陰若狭冷水域は，従来多くの人の指適している若狭湾沖冷水域の盛衰を示す事に他ならない。

2）短期変動に見られる特徴

fig 6 の各図は1955年3月下旬より7月までの 200m.層水塩分布を示している。これらの各図は15日間隔が最短で，約1ケ月間隔がほとんとである。冷水域の変化は実際には前述の如くごく短期間に著しい変貌が行われているので，充分とは云い難いが，その変化の大勢を考えよう。fig. 6 の各図には山陰若狭冷水域の存在がみられるが，この冷水域は前述の如く東西に2つの中心部をもつ場合と，経ケ岬沖合に一つの中心部をもつ場合とがある。すなわち，3月下旬には隠岐北方に温度勾配の少ない中心示度 2°C. の弱い冷水域と，経ケ岬沖

合70浬に範囲の広い，中心示度1.79°C.の大冷水域とがある。4月上旬には隠岐北東に中心示度1.39°C.，若狭湾北方に中心示度2.80°C.の2つの冷水域が明瞭となる。5月上旬の冷水域の配置も4月上旬と同じ位置にあるが，6月上旬では3月下旬と同じように経ケ岬沖に大冷水域（中心示度 2.15°C.）が存在し，6月には再び2つの冷水域に分れている。このような傾向は隠岐島北方の冷水域が次第に発達しながら東へ移動している状態を示すものである。

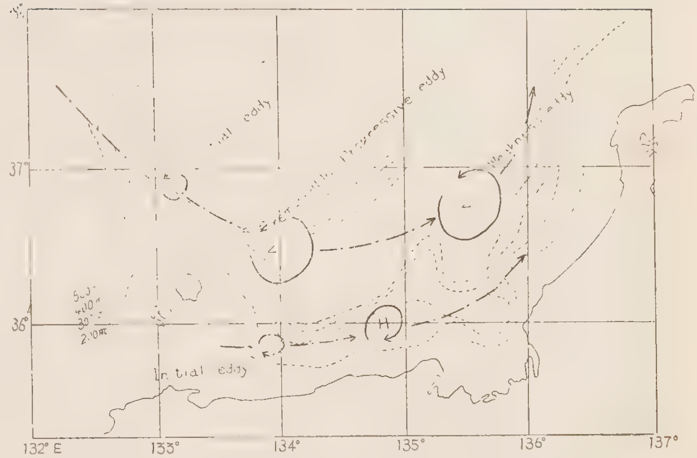


Fig. 7 Process of the Sanin'-Wakasa low and high temperature regions (counter-clockwise and clockwise eddies).

3月下旬における隠岐北方の冷水域（中心示度 2.18°C.）を出発点としてさらにその変化を追跡してみよう。fig. 6から，その変化を取纒めると，3月下旬隠岐北方に認められる冷水域は中心示度を降下し，その範囲を拡大しつつ隠岐東方へ移動しているが，5月上旬に最も発達し，その後次第に衰弱（中心示度の上昇），7月上旬には若狭湾沖においては中心示度高く，その範囲も著しく狭くなつている。このような冷水域変化の傾向は冷水域が一つの渦流であつて，発達の初期には中心附近の速度が著しく大きく（中心水温示度の低下），後期には速度が次第に低くなり，最大速度の部分は中心から離れて行く（中心水温の上昇，冷水域範囲の拡大）。すなわち換言すれば角運動エネルギー保存則が働く。McEwen (1948)は，南 California 沖の冷水域についてこのような理論が実際とよく一致する事を示したが，山陰若狭冷水域の変化においてもまつたく同一傾向をもつていると云える。

3) 機　　構

山陰若狭冷水域は経年変化や短期変動に見られるように，その中心位置の南北方向の振動は小なるに反し，東西方向の振動は大である事から，一つの低温帯に沿つて西から東へ移動している事を述べた。したがつて東西方向の変化のみ考えればよい。このような型は一面では比較的単純な要素に起因するものである事を示唆している。いま渦流生起の要因を考えると，前述の海嶺による地形性渦流・海盆による静振および卓越風による stress 等複雑な要因の組合せによると思はれるが，山陰若狭冷水域については，南北振動が経年的にもまた季節的にもほとんど一定と見てよいから，静振や風の stress 等よりもその主因となるものは隠岐島およびその北方に張り出した海嶺にあると考えられる。

隠岐島およびその北方海嶺によつて東行暖流が擾乱を受けているとすれば，山陰若狭冷水域はその周期性および発達—減衰の特性から，von Kármán's 渦列に似た，冷水域と暖水域の非対称型配列をもつていると見なされる。1955年3～8月の山陰若狭海域について見ると渦動系間の距離は約60浬(東西)，2つの渦列間の距離は約30浬（南北）であり，その渦列全体の速度は東へ1個月に約40浬であると概算される。そして Long. 134°E 附近で冷水域—左旋の渦流—はもつとも発達（中心水温の降下・周縁温度傾度の増大）し，その後減衰する（fig. 7）。

以上述べた事柄から，山陰若狭冷水域の変動予知には，特に隠岐北方の初期渦流の状態を知る事が必要であり，約1個月前に予測する事が可能と考えられる。

3　隠岐NW冷水域と島根冷水域

隠岐島と鬱陵島の中間附近に存在する冷水域は各観測を通じて認められ，その規模も中心位置もほとんど変化なく，非常に安定したものである，1932年および1946年は6月であつて，他の各観測より約2ケ月早い時期の状態であるがその時期では中心位置が北方へ転している。この冷水域の北方は暖流第3分枝主軸によつて

200m. 層附近の深度まで明らかに北方の寒流系水と cut off されている。そしておよその規模（50m.層）は直径60浬で，ENE から WSW の方向へ傾いた軸をもつ楕円形状をとり，周縁水との水温差は非常に大きい（約10°C.)。1955年8月に観測されたこの冷水域から，山口県沖30浬附近の，すなわち，**島根冷水域**（巾約15浬）の存在を暗示するが，観測線の関係で他の年における**島根冷水域**は認められない。**島根冷水域**はまた，1955年8月における T—Cl 曲線に示される如く，中層水塊以深では他の暖水域の性状と同じであり，表層水塊のみ低温性を示し，その構造が他の冷水域と全く異なると考えられる。そしてそれが沿岸近くに存在するため，漁況変動や漁場の移動に密接な関係をもつが，その関係は**島根冷水域**の規模や特性から山陰沖冷水域よりもさらに短期的な調査を要すると思われる。

4　能登冷水域

能登北西 120浬附近には大規模な渦流が存在するが，それは変化が著しく，年により冷水域あるいは暖水域の性格をもつ。ここでは冷水域に中心を置こう。概観的に1941年・1946年・1948年の観測では大規模な顕著な冷水域となつているが，1932年・1949年・1955年の各年は著しく小規模となつて暖水域が大部分を占める。しかしながらこれらの，冷・暖水域の規模はこの附近の観測が最小距離約30浬，最大距離 100浬以上であつて，山陰沖で述べたような小規模な渦流として観察できないとは言え，前述の如くこの海域では経年的な大変化が示される事は確かである。そしてその中心位置の変化は小規模な冷水域を示す場合その冷水域中心は東へ偏り，その西側に接して大規模な右旋渦流（暖水域）を見るが，大規模な冷水域の存在するときその中心位置はほとんど経年的にも変化しない。

5　佐渡冷水域

佐渡N70浬附近にしばしば冷水域が出現する。著者等（1952）は1950年の観測からこの冷水域の詳細な解析を行い，それが山陰沖冷水域と異なつて極前線の南偏である事を述べた。しかし年によつて北方**C冷水域**との間に上層部で cut off される場合があり，極前線の舌状南下部が発達して終りに cut off されると云う過程が考えられる。この cut off されないものは年によつて周縁水との温度勾配が他の一般の冷水域と異なり，非常に小なる時（高温部との水温差 2°C. 以内）があり，初期過程にある事を示唆している。各年の状況からみると，一般に周縁水との温度勾配の顕著な時には極前線の南偏の形をとる事が多いと考えられる。その中心位置は1941年において最も西偏し，能登北方に見られた。最も接岸した時は1948年であつて，佐渡N30浬附近にある。1949年は最東偏しているが，南西方向に周縁温度傾度の小さい冷水帯の一部となつている。渦流の規模は1946年において最大直径（80浬）を示し，西方に中心の位置するもの程規模が大きく，東に存在するものは規模が小さい。その最小規模は1949年にみられるものである。

6　山形沿岸冷水域

この冷水域は1932年・1941年においてみられるように，入道埼から佐渡海峡に至る間の沿岸の低温現象であつて，温度勾配は比較的緩かであり，その特性は**佐渡冷水域**の周縁温度勾配の少ない時の特徴と似ている。

7　北方冷水域

大和堆附近と N40° 以北の地域は観測が非常に少なく，経年的変化もごく概観的にしか明らかにできない。**北方冷水域**は東の **C 冷水域**のみ観察されるが，その西方海域の状態は明らかでない。1932年・1941年・1955年の各図からこの海域では**北方 B・C 冷水域**が春風堆附近を東行する暖流第3分枝の流路によつて cut off される場合と，cut off されない場合がある事が想像できる。

The Oceanographical Conditions of the Japan Sea and Its Water Systems, laying Stress on the Summer of 1955

by

Toshimasa SHIMOMURA and Kazuo MIYATA

Summary

1) No oceanographical investigation across the Liman Front had been carried out in the Japan Sea since Maritime Safety Board made it in August, 1943. Since the Tsushima Danryu Kaihatsu Chosa (the "General Survey on the Warm Tsushima Current") was commenced in April, 1953, the knowledge for the sea conditions, fishing conditions, and biology in the neritic waters of the Current increased rapidly. These swift developments have required the enlargement of knowledges on the offing. Consequently, the authors and their members made an offshore investigation through the Japan Sea east of long. 134°E., during the period August 13 - September 1, 1955. The main purpose of this investigation was as follows.

i) Oceanographical research of offshore "low temperature regions" where produce a powerful effect upon the inshore fisheries of the Japan Sea.

ii) Research of horizontal and vertical distribution of fish eggs, larval fishes, plankton, and Euphasidae and of relations to the sea conditions (water masses).

iii) Research of the bottom contours, and so forth.

2) This thesis deals with general view of the sea conditions of the Japan Sea in August, 1955 (Ch. 1), oceanographical changes of the Tsushima Current in the Japan Sea (Ch. 2), and oceanographical studies of the main "low temperature regions" in the Sea (Ch. 3).

In Chapter 1, the horizontal distribution of each oceanographical factors—water temperature, chlorinity, dissolved oxygen, oxygen saturation, colour and transparency of sea water, and hydrogen-ion concentration—are studied at each layer from the sea surface to 1,000-meter layer, and also the vertical distribution in six longitudinal sections reaching 2,000-meter depths is dealt. Then, the conspectus of the water systems in the Japan Sea are stated.

3) Recently, the Japan Sea, especially the northern part, keeps on to rise in its water temperature; the sea conditions of the Japan Sea in August 1955 are compared with those in August 1954. Namely, the stretch of the warm Tsushima Current in the year 1955 spreads out toward the farther north compared with that in 1954.

4) Seeing the oceanographical structures of the warm Tsushima Current and the yearly changes of volume transport of the Current, relation to the fishing conditions of "oba-iwashi" (large sardine) in the waters north of Ishikawa Pref. is studied, in the year when the offshore branches of the Tsushima Current are powerful, the catch shows a low level.

5) The main "low temperature region"-ten - in the Japan Sea are stated. Their oceanographical characteristics are studied. From the angle of their yearly, seasonally variation in position and oceanographical characteristics, there found the following five types.

i) Stationary type.

Yamato-tai Low Temperature Region,

Oki-NW L. T. R.,

San'in-Wakasa L. T. R..

ii) Variable type

Shimane L. T. R.,

Sado L. T. R..

iii) Variable but lasting type

Noto L. T. R.,

Yamagata-engan L. T. R..

iv) Variable-in-characteristrcs type.

Sado L. T. R..

v) Pure cold-water type.

"A" L.T.R.,

"B" L.T.R.

"C" L.T.R..

"Stationary type" low water temperature region is caused by the bottom topography (elevation of the sea floor). Yamato-tai Bank is the typify.

6) Seeing the short time variation in the position of **San'in-Wakasa Low Temperature Region,** it shows, above the continental shelf running toward north from the Oki Islands, a "von Kármán's vortex street" like grouping. The early vortex is found north of Oki Is., and it shows the largest development in long. 134°E and thereabouts, dwindling away in the farther eastern warters. Its eastward drifting is about 40 nautical miles a month.

引用文献

須田晥次他（1932）　第2回日本海南部海洋観測報告（第1報），海洋時報 **3**（2）

須田晥次他（1932）　第2回日本海南部海洋観測報告（第2報），海洋時報 **3**（3）

須田晥次他（1932）　第3回日本海主要部海洋観測報告，海洋時報 **4**（1）

宇田　道隆（1932）　日本海及び其の隣接海区の海況，水産試験場報告 5

水産試験場（1941）　海洋調査要報，**69**

海上保安庁（1947）　昭和21年夏の対馬海流々域の海象，水路要報 1

George F. McEwen (1948) The dynamic of large horizontal eddies (axes vertical) in the ocean off Southern California. *J.M.R.* **7** (3)

海上保安庁（1950）　昭和23年夏の対馬海流及び宗谷海流々域の海象，水路要報増刊号（海象編）

海上保安庁（1950）　昭和24年8月から10月の間に行つた海象観測成果表，水路要報増刊号 7

日高孝次他（1950）　対馬海流の永年変化について，日本海洋学会誌 **6**（1）

宮崎　道夫（1952）　日本海の熱経済，北海道区水産研究所研究報告 **4**

W. L. Ford and A. R. Miller (1952) The surface layer of the Gulf Stream and adjacent waters. *J.M.R.* **11** (3)

H. U. Sverdrup et al. (1952) The oceans. 4dt., New York, Prentice-Hall

下村敏正・宮田和夫（1953）　佐渡沖冷水域の海洋学的性状—1，日本水産学会誌 **19**（4）

California Cooperate Oceanic Fisheries Investigations (1953) Progress Report, 1 July 1952 to 30 June 1953. State of California Department of Fish and Game Marine Research Committee.

川合　英夫（1954，1955）　東北海区における極前線帯とその変動について，東北海区水産研究所研究報告 **4，5**

下村　敏正（1954）　海況による漁況予報—北部日本海の大羽いわし漁を中心として—，科学 **24**（10）

第八管区海上保安本部（1955）　日本海南西部海域（Q線）観測報告，海洋概報 1，2

下村敏正・宮田和夫（1956）　漁況変動の主因たる日本海冷水域の特性について，水産庁・対馬暖流開発調査第4回シンポジウム発表論文集

Oceanographical Data of the Japan Sea during the Period August 13～31, 1955

Explanation

1. Color of the sea : in Forels scale.
2. Tansparency : in metres. Figures in parentheses on the right of "Transparency" indicate the wire angle in degrees.
3. Wind wave : in the scale (0～9)
4. Swell : in the scale (0～9)
5. Depth : in meters determined by the wire length and its angle. When the depth is measured by unprotected thermometer, the value is marked with an asterisk *.
6. P_2O_5-P, SiO_2-Si, N_2O_3-N, N_2O_5 N, and alkalinity were chemically analized by Yoshiuki MATSUE and his members.
7. PH with a symbol * (sts.29～43) was also measured by the above members, corrected with water temperature.

											Interpolated		
Observed													
Depth m.	Temp °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-niuy	Depth m.	Temp. °C.	Cl ‰

St. 1 Date: Aug. 13, 1955 Time: 10 : 00—12 : 10 Lat.: 40°34′.4 N Long.: 139°38′.7 E Depth: 700m.

Depth m.	Temp °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-niuy	Depth m.	Temp. °C.	Cl ‰
0	26.5	—	—	—	8.2						0	26.5	—
10	21.57	18.97	4.82	92.1	8.2						10	21.57	18.97
25	14.41	18.98	6.01	101.4	8.2						25	14.41	18.98
50	—	18.98	5.87	—	8.2						50	14.26	18.98
75	14.12	19.07	5.25	88.2	8.2						75	14.12	19.07
99	12.59	19.03	5.66	93.2	8.2						100	12.49	19.03
173	5.49	18.92	6.14	86.5	8.2						150	7.70	18.95
242	2.83	18.91	6.56	87.0	8.2						200	4.45	18.92
331*	0.94	18.84	5.62	71.0	8.2						300	1.60	18.86
430*	0.33	18.82	6.11	76.0	8.2						400	0.51	18.83
628*	0.16	18.86	5.59	69.2	8.2						600	0.18	18.85

Sea color	Tansparency	Wind wave	Swell	Wind	Cloud	Weatrher
2.5	29m.(15°)	NNW/1	NNW/1	NNW/1	0	○

Vertical haul ("maru-toku" net):0∼50m.(15°)

Horizontal tow ("maru-chi" net): 10 minutes at about 2 knots

St. 2 Date: Aug. 13, 1955 Time: 13 : 55—15 :25 Lat.: 40°35.′0 N Long.: 139°15.5′ E Depth: 2,900m.

Depth m.	Temp °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-niuy	Depth m.	Temp. °C.	Cl ‰
0	26.0	18.86	—	—	8.2						0	26.0	18.86
10	26.23	18.86	4.84	99.8	8.2						10	26.23	18.86
25	19.94	18.94	5.80	107.7	8.2						25	19.94	18.94
50	12.83	18.93	6.63	108.8	8.2						50	12.83	18.93
75	10.18	18.94	5.99	93.3	8.2						75	10.18	18.94
100	7.68	18.93	6.04	89.3	8.2						100	7.68	18.93
150	4.20	18.81	6.12	83.6	8.0						150	4.20	18.81
200	1.95	18.83	6.34	82.1	7.9						200	1.95	18.83
300	0.71	—	5.10	—	7.8						300	0.71	(18.83)
400	0.35	18.82	6.47	80.5	7.8						400	0.35	18.82
605*	0.15	18.89	5.45	67.5	7.7						600	0.15	18.89
788*	0.23	18.87	5.27	65.3	7.7						800	0.22	18.87
1,000*	0.13	18.84	5.30	65.5	7.7						1,000	0.13	18.84
1,485*	0.08	18.82	5.60	69.2	7.7						1,500	0.08	18.82
2,178*	0.12	18.85	5.45	67.4	7.7						2,000	0.11	18.84

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	30m.(45°)	N/3	N/1	N/3	0	○

Vertical haul ("maru-toku" net) 0∼50m. (12°)

Horizontal tow ("maru-chi" net) : 10 minutes at abcut 2 knots.

St. 3 Date: Aug. 13, 1955 Time: 17 : 33—21 : 05 Lat.: 40°36′.2 N Long.: 138′51.2 E Depth: -

	Observed										Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
)	25.8	18.82	—	—	8.2						0	25.8	18.82
14	19.80	18.90	5.78	107.0	8.2						10	21.51	18.90
29	13.59	18.92	6.84	113.8	8.2						25	19.39	18.91
52	8.44	18.92	6.18	92.7	8.1						50	8.89	18.92
76	6.44	18.93	5.99	86.2	8.1						75	6.52	18.93
100	4.40	18.84	6.15	84.5	8.0						100	4.40	18.84
212	0.86	18.83	6.80	85.8	7.9						150	2.82	18.84
259	0.65	18.83	6.84	85.8	7.9						200	1.24	18.83
353*	0.37	18.82	6.22	77.5	7.9						300	0.53	18.83
446*	0.24	18.87	6.05	75.1	7.8						400	0.30	18.85
627*	0.15	18.79	5.38	66.6	7.7						600	0.16	18.80
1,04*	0.09	18.84	5.38	66.6	7.7						800	0.13	18.81
1,242*	0.09	18.79	5.48	67.7	7.6						1,000	0.10	18.83
1,702*	0.11	18.79	5.46	67.5	7.6						1,500	0.10	18.79
2,323*	0.11	18.80	5.44	67.2	7.7						2,000	0.11	18.80
2,766*	0.15	18.80	6.58	81.4	7.7						2,500	0.13	18.80

Sea colro	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	25m.(—)	N/3	N/1	N/3	0	○

Vertical haul ("maru-toku" net) : 0~50m (34°)
Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 4	Date	Time	Lat.,	Long.	Depth
	Aug. 13—14,1955	23 : 00—01 : 10	40°35.0 N	138°26.'0 E	>3,000m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	24.4	18.61	—	—	8.2						0	24.4	18.61
10	24.67	18.61	5.42	108.5	8.2						10	24.67	18.61
25	12.06	18.79	7.93	128.0	8.2						25	12.06	18.79
50	5.80	18.78	8.88	126.0	8.2						50	5.80	18.78
75	3.37	18.78	6.57	87.9	7.9						75	3.37	18.78
100	2.13	18.81	7.48	97.3	7.9						100	2.13	18.81
169	0.85	18.77	6.41	80.8	7.8						150	1.20	18.78
217	1.08	18.79	6.65	84.3	7.8						200	1.00	18.78
287*	0.38	18.78	6.24	77.6	7.8						300	0.36	18.78
386*	0.22	18.79	5.92	73.4	7.7						400	0.21	18.79
567	0.09	18.79	5.49	67.8	7.7						600	0.09	18.79
755*	0.08	18.80	5.51	68.1	7.7						800	0.08	18.80
938*	0.07	18.80	5.47	67.6	7.7						1,000	0.08	18.80
1,182*	0.09	18.80	5.43	67.2	7.7						1,500	0.15	18.81
1,485*	0.15	18.81	5.61	69.5	7.7						2,000	0.14	18.82
2,175*	0.14	18.83	5.89	72.8	7.7						2,500	0.17	—
2,655*	0.19	—	—	—	—								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	W/3	W/1	W/4	0	○

Vertical haul ("maru-toku" net) : 0~50m. (10°)
Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
Observed											Interpolated		

St. 5 Date Aug. 14, 1955 Time 03 : 08—06 : 10 Lat. 40° 35′.0 N Long. 138°01.0 E Depth >2,500m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	24.2	18.66	—	—	8.2						0	24.2	18.66
10	24.45	18.67	5.18	103.4	8.2						10	24.45	18.67
25	13.20	18.74	7.39	121.8	8.2						25	13.20	18.74
50	6.65	18.80	8.06	116.5	8.2						50	6.65	18.80
74	3.79	18.80	7.10	96.2	8.0						75	3.74	18.80
99	2.42	18.79	6.90	90.4	8.0						100	2.39	18.79
163	0.77	18.80	6.69	84.2	7.8						150	1.11	18.80
210	0.60	18.82	6.94	86.9	7.9						200	0.64	18.82
308	0.34	18.80	6.58	69.4	7.8						300	0.36	18.80
404	0.21	18.79	7.21	89.4	7.8						400	0.22	18.79
604*	0.15	18˙78	5.73	70.9	7.7						600	0.15	18.78
1,011*	0.08	18.79	5.42	67.0	7.7						800	0.12	18.78
1,189*	0.08	18.79	5.46	67.5	7.7						1,000	0.08	18.79
1,˙656*	0.15	18.80	5.50	68.0	7.6						1,500	0.13	18.80
2,066*	0.16	18.80	5.70	70.5	7.6						2,000	0.16	18.80
2,220*	0.16	18.81	6.82	84.4	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	25m.(40°)	N/3	N/1	N/4	CiAc/6	⏀

Vertical haul ("maru-toku" net) :0∼50m.(15°)

Horizontal tow ("maru-chi" net) : 10 minutesatabo ut 2knots

St. 6 Date Aug. 14, 1955 Time 14 : 00 Lat 40° 07.5 N Long 139°07′0 E Depth 2,129m

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	25.1												

Seacolor	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	———	E/N/1	E/N/1	E/N/2	Ciu/10	◎

St. 7 Date Aug 14, 1655 Time. 16 : 15 Lat. 40°00′.0 N Long. 139°21′.0 E Depth ca1,500m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	26.2												

Seacolor	Transpaerncy	Wind wave	Swell	Wind	Cloud	Weather
—	—	E/N/1	—/1	E/N/2	CiCu/10	◎

St. 8 Date Aug 15. 1955 Time 19 : 35—21 : 30 Lat. 39°25′.5 N Long. 138°39′.6 E Depth 950m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	25.8	18.89	—	—	8.2						0	25.8	18.89
11	26.04	18.96	5.07	104.3	8.3						10	26.04	18.95
25	20.12	19.˙03	5.86	109.2	8.3						25	20.12	19.03

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
50	16.04	19.05	5.96	103.7	8.2						50	16.04	19.05
75	14.36	18.99	5.42	91.4	8.2						75	14.36	18.99
100	12.27	18.93	5.74	93.1	8.2						100	12.27	18.93
149	10.18	18.90	5.97	93.0	8.2						150	10.18	18.90
275*	5.18	18.88	6.44	90.0	8.0						200	8.16	18.89
362*	1.40	18.88	5.89	75.3	7.8						300	4.09	18.88
458*	0.51	18.88	5.50	68.8	7.7						400	1.05	18.88
650*	0.24	18.88	5.33	66.1	7.7						600	0.31	18.88
843*	0.13	18.88	5.39	66.8	7.7						800	0.15	18.88

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	NE/1	—/2	NE/3	Cu/10	◎

Vertical haul ("maru-toku" net) : 0~50m. (15°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 9

Date	Time	Lat.	Long.	Depth
Aug. 15–16, 1955	23 : 15—00 : 20	39°18′.5 N	138°53′.7 E	260m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	26.2	—	—	—	8.3						0	26.2	—
10	26.17	18.87	5.65	116.4	8.2						10	26.17	18.87
25	20.21	19.08	6.01	112.2	8.2						25	20.21	19.08
50	16.56	19.14	6.23	109.4	8.2						50	16.56	19.14
75	14.50	19.14	5.52	93.6	8.2						75	14.50	19.14
100	12.73	19.07	5.84	95.7	8.2						100	12.73	19.07
150	10.35	18.99	6.12	95.7	8.1						150	10.35	18.99
196*	9.26	18.95	6.18	94.6	8.1						200	9.07	18.94
226*	7.84	18.91	6.25	92.8	8.1								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	ESE/1	—/1	ESE/1	—/5	⏀

Vertical haul ("maru-toku" net) 0~50m.(10°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 10

Date	Time	Lat.	Long.	Depth
Aug. 16, 1955	02 : 10—03 : 17	39°08 .0 N	139°12′.0 E	870m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	26.4	18.73	—	—	8.2						0	26.4	18.73
10	26.35	18.83	5.38	111.1	8.2						10	26.35	18.83
25	20.59	18.96	6.16	115.9	8.2						25	20.59	18.96
50	16.52	19.04	6.00	105.2	8.2						50	16.52	19.04
75	15.83	19.05	5.95	103.1	8.2						75	15.83	19.05
100	13.07	19.12	6.07	102.0	8.2						100	13.07	19.12
164*	10.42	18.96	6.12	95.8	8.1						150	11.00	19.00
213*	9.35	18.97	6.19	94.8	8.1						200	9.63	18.97
310*	3.13	18.91	5.34	71.4	7.9						300	3.77	18.92
407*	0.92	18.90	5.66	71.5	7.8						400	1.08	18.90

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m	Temp. C.	Cl ‰
612*	0.23	18.90	5.32	66.1	7.7						600	0.27	18.90
818*	0.15	18.89	6.33	78.4	7.7						800	0.16	18.89

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	WSW/W/1	—/1	WSW/W/0	—	—

Vertical haul ("maru-toku" net) : 0~50m.(6°)

Horizontal tow ("maru chi" net) : 10 minutes at about 2 knots

St. 11 Date Aug. 16, 1955 Time 05 : 10—05 : 35 Lat. 39°08′.0 N Long. 139°31′.0 E Depth 135m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m	Temp. C.	Cl ‰
0	26.8	18.67	—	—	8.2						0	26.8	18.67
10	26.73	18.83	5.13	106.7	8.2						10	26.73	18.83
25	22.28	19.01	5.09	98.5	8.2						25	22.28	19.01
50	17.50	19.07	6.14	109.6	8.2						50	17.50	19.07
75	15.04	19.13	5.76	98.6	8.2						75	15.04	19.13
100	13.10	19.14	5.36	96.9	8.1						100	13.10	19.14

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	21m.(1°)	WSW/1	—/1	WSW/1	CiCu/10	⦶

Vertical haul ("maru-toku" net) : 0~50m. (10°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 12 Date Aug. 16, 1955 Time 06 : 00—06 : 25 Lat. 39°06.′5N Long. 139°34′.0E Depth 340m

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m	Temp. C.	Cl ‰
0	26.8	18.74	—	—	8.2						0	26.8	18.74
11	24.36	18.83	5.42	108.1	8.2						10	24.58	18.83
26	21.02	19.02	5.91	112.0	8.2						25	21.24	19.01
50	16.98	19.14	6.42	113.7	8.2						50	16.98	19.14
75	15.18	19.15	6.42	110.0	8.2						75	15.18	19.15
100	11.53	19.09	6.75	108.1	8.1						100	11.53	19.09
159	9.68	18.97	6.59	101.7	8.1						150	9.96	18.[illegible]
218*	5.73	18.88	6.26	88.5	8.0						200	6.94	18.91
312*	0.99	18.88	5.79	73.3	7.9						300	1.60	18.88

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	WSW/1	—/1	WSW/1	CiCu/10	⦶

Vertical haul ("maru-toku" net) : 0~50m. (10°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 13 Date Aug. 16, 1955 Time 07 : 00—07:30 Lat. 39°05′.8 N Long. 139°41′.3 E Depth 110m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m	Temp. C.	Cl ‰
0	27.0	18.75	—	—	8.2						0	27.0	18.75
10	24.46	18.82	5.19	104.1	8.2						10	24.64	18.80

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
25	22.20	18.92	5.38	103.8	8.2						25	22.20	18.92
50	20.91	19.01	5.31	100.1	8.2						50	20.91	19.01
75	18.19	19.06	5.70	103.0	8.2						75	18.19	19.06
100	13.26	19.06	5.54	91.7	8.1						100	13.26	19.06

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	27m.(3°)	SE/2	—/1	SE/2	Cu/8	◎

Vertical haul ("maru-toku" net) : 0～50m. (11°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 14	Date	Time	Lat.	Long.	Depth
	Aug. 19, 1955	20 : 00—21 : 16	39°02′.8 N	138°10′.0 E	1,300m.

0	25.1	18.84	—	—	8.2						0	25.1	18.84
18	23.20	18.94	5.28	103.5	8.2						10	24.04	18.90
32	19.10	19.01	5.99	109.9	8.2						25	21.15	18.98
55	16.21	19.09	5.70	99.4	8.2						50	16.84	19.07
76	15.20	19.10	5.71	97.9	8.2						75	15.25	19.10
101	14.84	19.09	5.91	100.8	8.2						100	14.85	19.09
210	8.90	18.87	5.78	87.6	8.1						150	12.17	18.99
274*	6.70	18.84	5.98	86.5	8.2						200	9.45	18.89
378*	1.22	18.84	5.46	69.5	7.8						300	5.33	18.84
476*	0.68	18.82	5.12	64.3	7.6						400	1.10	18.84
680*	0.26	18.82	5.03	62.6	7.6						600	0.42	18.82
926*	0.15	18.82	5.69	70.5	7.6						800	0.21	18.82
1,115	0.10	18.84	5.29	65.4	7.6						1,000	0.13	18.83

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	WSW/3	WSW/2	WSW/4	—	◑

Vertical haul ("maru-toku" net) : 0～50m. (36°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 15	Date	Time	Lat.	Long.	Depth
	Aug. 20, 1955	00 : 45—02 : 50	39°25′0 N	137°55′0 E	2,400m.

0	25.5	18.65	—	—	8.2						0	25.5	18.65
16	23.05	18.85	5.17	101.0	8.2						10	23.20	18.78
30	19.28	19.07	5.50	101.1	8.2						25	20.63	18.99
35	15.82	19.06	5.73	99.2	8.2						50	16.27	19.06
77	13.65	19.08	5.66	94.4	8.2						75	13.83	19.08
100	12.27	19.01	5.38	87.4	8.2						100	12.27	19.01
209	8.92	18.97	5.75	87.2	8.1						150	10.73	18.99
253*	6.86	18.86	5.81	84.5	8.0						200	9.20	18.97
323*	2.40	18.85	5.69	74.5	7.8						300	3.87	18.85
402*	0.85	18.82	5.26	66.3	7.6						400	0.89	18.82
553	0.24	18.84	5.11	63.4	7.6						600	0.23	18.84

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
1,118*	0.08	18.83	5.19	64.2	7.6						800	0.17	18.84
1,204*	0.05	18.79	5.15	63.6	7.6						1,000	0.11	18.83
1,640*	0.17	18.82	5.76	71.3	7.6						1,500	0.13	18.81
2,034*	0.11	18.83	5.26	65.1	7.6						2,000	0.12	18.83

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	WSW/3	WSW/3	WSW/4	—	⦶

Vertica haul ("maru-toku" net) : 0~50m.(45°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 16 Date Aug. 20, 1955 Time 06 : 30—08 : 10 Lat. 39°50′.0 N Long. 137°37′.0 E Depth 27,00m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	26.1	18.64	—	—	8.3						0	26.1	18.64
14	26.04	18.65	4.58	94.0	8.3						10	26.06	18.65
29	19.64	18.88	5.59	103.1	8.2						25	21.35	18.82
53	15.56	19.05	5.58	96.5	8.2						50	16.07	19.03
77	11.77	18.99	6.24	100.1	8.1						75	12.08	19.00
100	10.28	18.98	5.40	84.4	8.1						100	10.28	18.98
189	3.60	18.86	5.78	77.9	8.1						150	6.53	18.91
196	2.79	18.83	5.77	76.3	7.8						200	2.73	18.83
320*	0.87	18.86	5.99	75.6	7.8						300	1.18	18.86
413*	0.46	18.82	6.88	85.9	7.7						400	0.52	18.83
628*	0.15	18.87	5.78	71.6	7.6						600	0.19	18.86
823*	0.07	18.85	5.23	64.7	7.6						800	0.08	18.85
1,006*	0.12	18.86	5.10	63.1	7.6						1,000	0.12	18.86
1,510*	0.12	18.87	5.35	66.2	7.6						1,500	0.12	18.87
1,946*	0.15	18.85	4.99	61.7	7.6								

Sea color	Trasparency	Wind wave	Swell	Wind	Cloud	Weather
—	22m.(—°)	WSW/4	WSW/3	WSW/4	StN/b7	⦶

Vertical haul ("maru-toku" net) : 0~50m.(21°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 17 Date Aug. 20, 1955 Time 11 : 05—12 : 31 Lat. 40°13′.5N Long. 137°19′.0E Depth 2,700m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	26.1	18.69	—	—	8.3						0	26.1	18.69
10	26.11	18.66	5.18	106.3	8.3						10	26.11	18.66
25	19.10	18.92	5.36	98.1	8.2						25	19.10	18.92
50	14.87	19.11	4.81	82.0	8.2						50	14.87	19.11
75	11.82	19.00	5.29	85.1	8.1						75	11.82	19.00
100	9.36	18.94	5.60	85.7	8.1						100	9.36	18.94
150	4.95	18.86	6.06	84.4	8.0						150	4.91	18.86
206*	2.32	18.86	6.84	89.4	7.8						200	2.60	18.86
314*	0.69	18.84	6.42	80.6	7.8						300	0.90	18.84

Depth m.	Temp. °C.	Cl ‰	O^2 cc./L	O^2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_2 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m.	Interpolated Temp. °C.	Interpolated Cl ‰
468*	0.56	18.84	6.20	77.7	7.8						400	0.62	18.84
590*	0.24	18.84	5.76	71.5	7.7						600	0.24	18.84
801*	0.15	18.88	5.31	65.8	7.7						800	0.15	18.88
1,010*	0.11	18.87	5.26	65.1	7.6						1,000	0.11	18.87
1,484*	0.11	18.87	5.40	66.8	7.6						1,500	0.11	18.87
1,711*	0.12	18.88	5.37	66.5	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
5	7m.(− °)	NW/2	NW/2	NW/2	Nb/7	⦶

Vertical haul ("maru-toku" net) : 0~50m.(0 °)
Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 18

Date	Time	Lat.	Long.	Depth
Aug. 20, 1955	15 : 35—17 : 40	40°35′.0 N	137°04′.0 E	3,300m.

Depth m.	Temp. °C.	Cl ‰	O^2 cc./L	O^2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_2 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m.	Interpolated Temp. °C.	Interpolated Cl ‰
0	25.5	18.93	—	—	8.3						0	25.5	18.93
11	24.81	18.91	4.72	95.0	8.2						10	24.87	18.91
26	13.36	18.91	7.14	118.1	8.0						25	14.12	18.91
50	8.39	18.89	6.46	96.8	8.0						50	8.39	18.89
75	5.82	18.86	6.72	95.5	8.0						75	5.82	18.86
100	3.48	18.86	6.24	83.9	8.0						100	3.48	18.86
206	0.65	18.87	6.19	77.6	7.8						150	2.14	18.86
257*	0.45	18.87	6.49	80.9	7.8						200	0.81	18.87
358*	0.28	18.88	6.70	83.4	7.8						300	0.38	18.87
447*	0.23	18.87	6.37	79.0	7.7						400	0.26	18.88
598*	0.15	18.88	5.29	65.5	7.5						600	0.15	18.88
653*	0.10	18.86	5.58	69.1	7.6						800	0.07	18.87
842*	0.06	18.87	5.24	64.8	7.6						1,000	0.06	18.85
1,032*	0.06	18.84	5.33	65.9	7.6								
1,091*	0.09	18.86	5.81	71.9	7.5								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	20m.(1°)	NW/2	—/1	NW/3	CuCs/3	⦶

Vertical haul ("maru-toku" net) : 0~50m.(26°)
Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 19

Date	Time	Lat.	Long.	Depth
Aug. 21, 1955	03 : 00—04 : 28	40°34′.0 N	136°04′.0 E	ca.1,500m.

Depth m.	Temp. °C.	Cl ‰	O^2 cc./L	O^2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_2 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m.	Interpolated Temp. °C.	Interpolated Cl ‰
0	24.4	18.71	—	—	8.1						0	24.4	18.71
10	24.61	18.70	6.37	127.7	8.1						10	24.61	18.70
25	8.59	18.79	8.17	122.9	8.1						25	8.59	18.79
50	4.04	18.83	7.40	100.9	8.0						50	4.04	18.83
75	2.45	18.83	6.63	86.9	8.0						75	2.45	18.83
99	1.48	18.87	6.67	85.5	7.8						100	1.47	18.87
160	0.75	18.85	6.96	87.5	7.8						150	0.87	18.85
204*	0.60	18.91	7.00	87.7	7.8						200	0.61	18.90

	Observed										Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C	Cl ‰
304*	0.25	18.85	4.72	58.6	7.6						300	0.26	18.85
314*	0.26	18.86	6.22	77.4	7.7						400	0.19	18.86
410*	0.18	18.86	5.98	74.1	7.7						600	0.11	18.85
610*	0.11	18.85	5.41	67.0	7.6						800	0.12	18.86
669*	0.08	18.86	5.44	67.3	7.6						1,000	0.13	18.86
817*	0.12	18.86	5.33	65.9	7.6								
1,317*	0.16	18.87	5.26	65.2	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	WNW/1	—/1	WNW/2	—	○

Vertical haul ("maru-toku" net) : 0~50m.(20°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 20 Date Aug. 21, 1955 Time 11 : 00—12 : 30 Lat. 40°32′.0N Long. 135°15′.0E Depth >3000m.

0	25.4	18.75	—	—	8.3						0	25.4	18.75
10	21.39	18.73	5.69	107.5	8.2						10	21.39	18.73
25	11.39	18.84	7.28	115.9	8.1						25	11.39	18.84
50	6.28	18.87	6.77	97.1	8.1						50	6.28	18.87
75	4.97	18.86	6.10	85.0	8.0						75	4.97	18.86
100	2.75	18.86	6.26	82.7	7.9						100	2.75	18.86
163	1.01	18.83	6.52	82.5	7.8						150	1.37	18.84
213*	0.59	18.83	6.42	80.5	7.8						200	0.70	18.83
305*	0.31	18.83	6.08	75.7	7.7						300	0.33	18.83
397*	0.19	18.84	5.85	72.5	7.7						400	0.19	18.84
517*	0.16	18.84	5.54	68.6	7.6						600	0.11	18.83
601*	0.11	18.83	5.31	65.7	—						800	0.06	18.88
843*	0.05	18.89	5.21	64.5	7.7						1000	0.13	18.86
1,023*	0.14	18.86	5.36	66.4	7.6								
1,464*	0.12	18.86	5.24	64.8	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
3	20m.(—°)	N/1	—/1	N/2	CuCs/5	◑

Vertical haul ("maru-toku" net) : 0~50m.(13°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 21 Date Aug. 21, 1955 Time 16 : 00—16 : 55 Lat. 39°58′.0 N Long 135°20′.0 E Depth 920m.

0	24.9	18.78	—	—	8.3						0	24.9	18.78
11	24.96	18.76	4.68	94.4	8.2						10	24.95	18.76
26	12.96	18.87	7.25	119.1	8.2						25	13.76	18.87
50	7.61	18.88	7·92	116.8	8.1						50	7.61	18.88
75	5.50	18.89	6.36	89.6	8.1						75	5.50	18.89
99	3.86	18.84	6.16	83.6	8.0						100	3.82	18.84

Depth m.	Temp. °C.	Cl ‰	O² cc./L	O² %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
	Observed										Inretpolated		
176*	1.15	18.86	5.88	74.7	7.7						150	2.06	18.85
177*	1.16	18.85	5.60	71.2	7.8						200	0.92	18.85
224*	0.67	18.85	6.06	76.1	7.8						300	0.32	18.83
281*	0.32	18.83	6.33	78.7	7.7						400	0.30	18.85
510*	0.28	18.87	5.92	73.7	7.6						600	0.23	18.87
808*	0.11	18.88	5.13	63.6	7.6						800	0.11	18.88

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	23m.(—°)	NE/2	—/1	NE/3	CcCu/3	◑

Vertical haul ("maru-toku" net) : 0～50m.(13°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 22 Date Aug. 21, 1955 Time 21 : 00 21 : 55 Lat. 39°47′0 N Long. 136°03′.0 E Depth 1,300m.

Depth m.	Temp. °C.	Cl ‰	O² cc./L	O² %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	24.8	18.76	—		8.1						0	24.8	18.76
11	24.46	18.74	4.78	95.5	8.2						10	24.49	18.74
26	12.29	18.90	7.11	115.3	8.1						25	13.10	18.89
50	7.99	18.88	7.62	113.3	8.0						50	7.99	18.88
75	5.15	18.89	6.08	85.0	7.9						75	5.15	18.89
100	3.71	18.87	6.28	84.9	7.8						100	3.71	18.87
172	1.30	18.87	5.79	73.9	7.8						150	2.04	18.87
217	0.69	18.87	5.79	72.6	7.8						200	0.92	18.87
325*	0.32	18.86	5.59	69.5	7.7						300	0.41	18.86
414*	0.22	18.85	5.12	63.5	7.7						400	0.24	18.85
604*	0.12	18.86	5.11	63.5	7.6						600	0.12	18.86
854*	0.13	18.86	5.29	65.5	7.6						800	0.13	18.86
1,048*	0.15	18.87	5.13	63.6	7.6						1,000	0.15	18.87

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	NE/2	—/1	NE/3	—	○

Vertical haul ("maru-toku" net) : 0～50m.(18°)

Horizontal tow ("maru-chi"net) : 10 minutes at about 2 knots

St. 23 Date Aug. 22, 1955 Time 02 : 00—03 : 25 Lat. 39°27′.0 N Long. 136°35′.0 E Depth >3,000m.

Depth m.	Temp. °C.	Cl ‰	O² cc./L	O² %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	25.4	18.88	—	—	8.3						0	25.4	18.88
10	25.51	18.88	4.60	93.7	8.2						10	25.51	18.88
25	18.20	18.88	5.87	105.9	8.2						25	18.20	18.88
50	11.50	18.89	6.79	108.3	8.2						50	11.50	18.89
75	7.84	18.89	6.63	98.4	8.1						75	7.84	18.89
100*	5.88	18.86	5.79	82.2	8.0						100	5.88	18.86
154*	2.70	18.86	6.31	83.3	7.8						150	2.94	18.86
215*	1.29	18.86	—	—	—						200	1.64	18.86
322*	0.42	18.86	5.09	65.0	7.6						300	0.60	18.86

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O^2 cc./L	O^2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
383*	0.23	18.86	5.16	64.0	7.6						400	0.22	18.87
413*	0.21	18.87	5.08	63.4	7.6						600	0.13	18.86
442*	0.18	18.87	4.91	60.9	7.6								
464*	0.21	18.87	4.90	60.7	7.6								
573*	0.17	18.87	5.21	64.5	7.6								
611*	0.12	18.86	5.00	62.0	7.6								

Sea color	Transparency	wind wave	Swell	Wind	Cloud	Weather
—	—	E/2	E/2	E/2	—	○

Vertical haul ("maru-toku" net) : 0~50m(11°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 24	Date	Time	Lat.	Long.	Depth
	Aug. 22, 1955	06 : 00--07 : 50	39°08′.0N	136°18′.0 E	2,700m.

0	25.5	18.89	—	—	8.3						0	25.5	18.89
10	25.57	18.86	4.59	93.7	8.3						10	25.57	18.86
25	17.90	18.94	6.16	110.6	8.3						25	17.90	18.94
50	10.74	18.92	6.83	107.6	8.2						50	10.74	18.92
75	7.82	18.89	6.74	100.0	8.2						75	7.82	18.89
99	5.76	18.84	5.93	83.8	8.0						100	5.70	18.84
149	3.00	18.86	6.00	79.7	7.8						150	2.97	18.86
197*	1.49	18.85	5.65	72.4	7.7						200	1.46	18.85
306*	0.46	18.85	5.96	74.4	7.7						300	0.52	18.85
372*	0.29	18.85	5.18	64.5	7.6						400	0.20	18.85
414*	0.17	—	—	—	—						600	0.12	18.84
599*	0.12	18.84	5.19	64.2	7.6						800	0.10	18.86
620*	0.09	18.86	5.16	63.9	7.6						1,000	0.12	18.86
810*	0.10	18.86	5.31	65.7	7.6						1,500	0.09	18.86
1,009*	0.12	—	5.22	—	7.7								
1,532*	0.09	18.86	5.41	66.9	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	22m.(— °)	N/3	N/3	N/2	Cu/3	⦶

Vertical haul ("maru-toku" net) : 0~50m.(21°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 25	Date	Time	Lat.	Long.	Depth
	Aug. 22, 1955	11 : 00—13 : 50	38°48′.0 N	136°39.′0 E	>4,000m.

0	25.6	18.60	—	—	8.3						0	25.6	18.60
10	25.13	18.64	4.98	100.6	8.2						10	25.13	18.64
25	18.53	18.99	5.60	101.5	8.2						25	18.53	18.99
50	16.01	19.07	5.15	89.5	8.2						50	16.01	19.07
75	13.94	19.05	5.55	93.0	8.2						75	13.94	19.05
100	10.32	18.94	5.62	87.8	8.2						100	10.32	18.94

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali -nity	Interpolated Depth m.	Interpolated Temp. °C.	Interpolated Cl ‰
159	4.37	18.84	6.09	83.5	8.2						150	5.28	18.86
208	2.16	18.80	6.00	78.2	7.8						200	2.52	18.81
290*	0.71	18.84	5.29	66.4	7.8						300	0.67	18.84
393*	0.33	18.83	5.18	64.5	7.8						400	0.32	18.83
581*	0.18	18.83	5.14	63.7	7.6						600	0.18	18.83
814*	0.15	18.84	5.09	63.0	7.7						800	0.15	18.84
1013*	0.13	—	5.19	—	7.7						1,000	0.13	18.84
1508*	0.10	18.84	5.26	65.1	7.7						1,500	0.10	18.84
2123*	0.17	18.84	5.25	65.1	7.6						2,000	0.16	18.84

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
3	19m.(—°)	NNE/3	NNE/4	NNE/3	Cu/4	⌽

Vertical haul ("maru-toku" net) : 0~50m.(11°)

Horizontal tow("maru-chi" net) : 10 minutes at about 2 knots

St. 26	Date	Time	Lat.	Long.	Depth
	Aug. 22, 1955	20 : 30—21 : 30	38°27′.0 N	137°09′.0 E	450m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali -nity	Interpolated Depth m.	Interpolated Temp. °C.	Interpolated Cl ‰
0	26.0	18.59	—	—	8.3						0	26.0	18.59
10	26.18	18.54	4.66	95.6	8.2						10	26.18	18.54
25	20.81	18.91	5.52	104.1	8.2						25	20.81	18.91
50	17.40	19.05	5.57	98.4	8.2						50	17.40	19.05
75	15.04	19.06	4.63	79.1	8.2						75	15.04	19.06
100	11.90	19.03	5.29	85.3	8.1						100	11.90	19.03
156*	7.54	18.87	5.79	85.4	8.0						150	8.01	18.89
207*	4.65	18.82	5.78	80.0	8.0						200	5.05	18.83
309*	1.09	18.83	5.25	66.6	7.6						300	1.40	18.83
397*	0.40	18.82	5.09	63.4	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	NE/3	NE/2	NE/1	—	○

Vertical haul ("maru-toku" net) : 0~50m.([illegible]°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 27	Date	Time	Lat.	Long.	Depth
	Aug. 23, 1955	03 : 10—04 : 28	38°04′.0 N	137°34′.0 E	1,300m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali -nity	Interpolated Depth m.	Interpolated Temp. °C.	Interpolated Cl ‰
0	25.8	18.60	—	—	8.3						0	25.8	18.60
11	25.98	18.52	4.83	98.8	8.2						10	25.99	18.53
26	22.06	18.88	5.12	98.5	8.2						25	22.32	18.86
51	18.60	19.04	5.24	95.2	8.2						50	18.74	19.03
76	16.65	19.08	5.25	92.5	8.2						75	16.73	19.08
100	14.30	19.09	5.41	91.4	8.1						100	14.30	19.09
174*	11.10	18.94	5.81	92.2	8.0						150	12.14	18.99
224*	8.67	18.84	5.64	85.0	—						200	9.84	18.89
324*	5.55	18.84	5.40	76.2	7.7						300	6.30	18.84

Observed											Interpolated		
Depth	Temp	Cl	O_2		PH*	P_2O_5	SiO_2	N_2O_3	N_2O_5	Alkali-nity	Depth	Temp.	Cl
m.	°C.	‰	cc./L	%		γ/L	γ/L	γ/L	γ/L		m.	°C.	‰
424*	0.56	18.85	5.23	65.5	7.7						400	1.76	18 85
638*	0.22	18.80	5.08	62.9	7.6						600	0.28	18.81
808	0.17	18.82	5.16	63.9	7.6						800	0.17	18.82
993*	0.09	18.84	5.24	64.9	7.6								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	—/1	0	—	—	○

Vertical haul ("maru-toku" net) : 0∼50m.(8°)

Horizontal tow ("maru-chi" net) : 10 minutes at abuot 2 knots

St. 28	Date	Time	Lat.	Long.	Depth
	Aug. 26, 1955	21 : 45—22 : 10	37°39.'5N	137°08'.5E	84m.

0	27.1				8.2								

Sea color	Transparency	Wind wave	Swell	Wind	Clond	Weather
—	—	—	—	—	—	—

Vertical haul ("maru-toku" net) : 0∼50m.(3°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 29	Date	Time	Lat.	Long.	Depth
	Aug. 27, 1955	02 : 20—03 : 20	38°03'.0 N	136°41'5 E	700m.

0	26.5	18.28	—	—	8.26						0	26.5	18.28
10	25.98	18.78	5.65	116.2	8.15						10	25.98	18.78
25	20.47	18.78	5.28	98.7	8.10						25	20.47	18.78
50	16.45	19.07	4.66	81.6	8.15						50	16.45	19.07
75	13.69	19.09	5.60	93.5	8.11						75	13.69	19.09
100	10.18	19.02	5.65	88.2	8.11						100	10.18	19.02
177*	3.07	18.93	5.83	77.9	7.92						150	5.56	18.96
218*	1.74	18.88	5.74	74.0	7.82						200	2.32	18.90
306*	1.13	18.88	5.22	66.2	7.71						300	1.17	18.88
402	0.48	18.86	5.49	68.7	7.71						400	0.48	18.86
595*	0.16	18.86	5.19	64.4	7.67								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	0	0	—	—	—

Vertical haul ("maru-toku" net) : 0∼50m.(2°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 30	Date	Time	Lat.	Long.	Depth
	Aug. 27, 1955	07 : 35—09 : 10	38°29'.7 N	137°07'.8 E	275m.

0	26.5	18.42	—	—	8.25						0	26.5	18.42
10	26.23	18.78	4.74	97.8	8.15						10	26.23	18.78
25	19.82	18.95	5.51	102.2	8.15						25	19.82	18.95
50	15.91	19.09	5.73	99.6	8.10						50	15.91	19.09
75	14.09	19.09	4.95	83.2	8.04						75	14,09	19.09

			Observed								Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
100	11.18	19.02	5.54	88.1	8.04						100	11.18	19.02
148*	6.28	18.90	5.99	86.0	8.00						150	6.28	18.90
200*	3.14	18.87	5.62	74.4	7.85						200	3.14	18.87
241*	1.54	18.83	5.73	73.6	7.75								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
2	24m.(13°)	0	0	0	CiCu/10	◎

Vertical haul ("maru-toku" net) : 0∼50m.(0°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 31

Date	Time	Lat.	Long.	Depth
Aug. 27, 1955	16 : 45—18 : 45	38°24′.5 N	136°11′.0 E	>1,500m.

0	26.2	18.80	—	—	8.24	1.3	133	0	0	2.39	0	26.2	18.80
10	25.46	18.88	46.7	95.1	8.24	1.2	144	0	1	2.33	10	25.46	18.88
25	17.30	18.94	6.46	114.7	8.24	1.2	192	0	1	2.33	25	17.30	18.94
50	11.06	18.95	6.98	110.8	8.18	5.3	178	0.1	3	2.33	50	11.06	18.95
74	7.92	19.00	6.63	98.8	8.08	7.8	165	0.9	2207	2.31	75	7.92	19.00
102	5.19	18.88	6.60	92.4	8.04	7.6	365	0.1	46	2.33	100	5.19	18.89
149	2.55	18.87	5.67	74.6	7.84	8.1	490	0.8	93	2.37	150	2.55	18.87
197	1.20	18.86	5.61	71.4	7.79	31.1	778	0.5	101	2.35	200	1.20	18.86
302*	0.34	18.86	5.10	63.5	7.70	34.5	1,006	1.0	134	2.36	300	0.34	18.86
455*	0.16	18.86	5.24	65.0	7.65	36.2	1,167	1.4	134	2.34	400	0.22	18.86
645*	0.15	18.88	5.17	64.1	7.65	47.4	1,202	—	79	2.37	600	0.15	18.88
848*	0.09	18.94	5.19	64.2	7.70	47.6	1,246	0	127	2.39	800	0.10	18.93
1,009*	0.10	18.90	5.26	65.1	7.70	37.7	1,437	0	143	2.37	1,000	0.10	18.90

Sea color	Transparency	Wind wave	Swell	Wind	cloud	Weather
2	21m.(27°)	N/1	0	N/2	—/10	●'

Vertical haul ("maru-toku" net) :0∼50m. (9°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 32

Date	Time	Lat.	Long.	Depth
Aug. 27, 1955	22 : 25—23 : 45	38°48′.0 N	135°42′0 E	>2,000m.

0	26.0	18.86	—	—	8.24						0	26.0	18.86
10	25.84	18.87	4.64	95.1	8.24						10	25.84	18.87
25	16.28	19.06	6.18	108.2	8.23						25	16.28	19.06
50	11.37	—	5.36	—	8.17						50	11.37	18.98
75	7.23	18.90	6.24	91.3	8.02						75	7.23	18.90
100	5.31	18.85	6.07	85.2	7.97						100	5.31	18.85
158*	2.51	18.86	5.78	76.0	7.88						150	2.90	18.86
207*	1.13	18.86	5.36	68.1	7.78						200	1.33	18.86
309*	0.33	18.86	5.15	64.2	7.68						300	0.40	18.86
415*	0.09	18.86	5.14	63.7	7.68						400	0.12	18.86

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m	Interpolated Temp. °C.	Interpolated Cl ‰
529	0.14	18.86	5.19	64.3	7.69						600	0.13	18.86
884	0.08	18.86	5.26	65.0	7.68						800	0.09	18.86
1,083*	—	—	5.25	—	7.68						1000	0.09	18.88
1,144*	0.10	18.89	5.26	65.2	7.63						1500	0.08	18.89
1,583*	0.07	18.89	5.29	65.5	7.68								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	NE/2	0	NE/3	Nb/10	●^{2}

Vertical haul ("maru-toku" net) : 0~50m.(3°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 33	Date	Time	Lat.	Long.	Depth
	Aug. 28, 1955	03 : 30—04 : 55	39°12′.5 N	135°17′.0 E	675m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m	Interpolated Temp. °C.	Interpolated Cl ‰
0	26.0	08.85	—	—	8.23	11.3	801	1.3	0	2.36	0	26.0	18.85
13	26.02	18.86	4.59	94.6	8.23	10.9	675	0.6	1	2.37	10	26.02	18.86
27	16.61	18.86	6.48	113.7	8.23	13.2	838	2.3	1	2.39	25	16.61	18.86
52	8.83	18.88	7.35	111.3	8.18	22.2	982	0.6	1	2.39	50	9.41	18.88
76	5.88	18.86	6.20	88.0	8.03	45.6	—	3.2	—	—	75	5.88	18.86
116*	3.77	18.86	6.16	83.4	7.94	39.5	982	—	130	2.41	100	4.61	18.86
166*	1.49	18.85	5.55	71.1	7.84	47.7	1,105	0.4	191	2.41	150	2.22	18.85
213*	0.88	18.84	5.73	72.4	7.79	55.8	1,460	0.4	212	2.41	200	1.05	18.84
316*	0.24	18.86	5.58	69.3	7.74	59.5	1,552	0.3	209	2.43	300	0.34	18.86
499*	0.15	18.86	5.25	65.2	7.74	64.6	1,543	0.5	254	2.43	400	0.20	18.86
674*	0.10	18.86	5.17	64.1	7.74	70.9	1,807	0.3	272	2.45	600	0.12	18.86

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	ESE/3	—/1	ESE/4	—/10	◕°

Vertical haul ("maru-toku" net) : 0~50m.(22°)

Horiozntal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 34	Date	Time	Lat.	Long.	Depth
	Aug. 28, 1955	08 : 00—09 : 00	39°34′0 N	134°50′0 E	700m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m	Interpolated Temp. °C.	Interpolated Cl ‰
0	25.4	18.73	—	—	8.23						0	25.4	18.73
5	25.75	18.73	4.62	94.3	8.19						10	12.53	18.82
12	7.24	18.86	7.32	107.3	8.13						25	6.05	18.86
26	6.05	18.86	6.65	95.0	8.08						50	4.40	18.86
51	4.40	18.86	6.22	85.5	7.98						75	3.42	18.86
75	3.42	18.86	5.87	78.8	7.93						100	2.55	18.86
100	2.55	18.86	5.80	76.4	7.78						150	1.78	18.86
191*	1.15	18.86	5.77	73.3	7.78						200	1.06	18.86
267*	0.40	18.86	5.47	68.3	7.78						300	0.36	18.86
356*	0.29	18.86	5.27	65.6	7.78						400	0.25	18.86
454*	0.19	18.87	5.20	64.6	7.74						600	0.11	18.87
651*	0.08	18.87	5.13	63.5	7.70								

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_2 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m.	Temp. °C.	Cl ‰
Observed											Interpolated		

Sea color 2 | Transparency 23m.(37°) | Wind wave SSE/3 | Swell —/1 | Wind SSE/4 | Cloud Cu/8 | Weather ◎

Vertical haul ("maru-toku" net) : 0~50m.(13°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 35 Date Aug. 28, 1955 Time 12 : 20—13 : 58 Lat. 39°52′.5N Long. 134°23′.0E Depth 1,050m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_2 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	25.9	18.75	—	—	8.23	2.8	131	0	0	2.35	0	25.9	18.75
10	25.78	18.68	4.66	95.2	8.23	1.4	157	0	0	2.31	10	25.78	18.68
25	16.47	19.02	5.88	103.0	8.12	2.7	195	0.5	0	2.34	25	16.47	19.02
50	9.62	18.89	6.60	100.3	8.07	4.3	173	—	0	2.37	50	9.62	18.89
80	5.92	18.86	5.96	84.8	7.98	3.0	228	0.6	49	2.39	75	6.54	18.87
103	4.30	18.86	5.81	79.7	7.93	21.8	318	0.4	98	2.34	100	4.51	18.86
150	2.11	18.86	6.03	78.6	7.83	26.0	435	1.1	98	2.33	150	2.11	18.86
197	1.03	18.86	5.94	75.3	7.78	37.2	630	1.1	154	2.37	200	1.02	18.86
413*	0.18	18.86	5.29	65.7	7.74	50.3	984	—	319	2.35	300	0.62	18.86
506*	0.18	18.85	5.12	63.5	7.69	—	1,003	0.5	214	2.33	400	0.23	18.86
701*	0.15	18.84	5.13	63.6	7.68	—	1,175	0.4	228	2.34	600	0.17	18.85
900*	0.10	18.81	5.15	63.7	7.68	67.0	1,216	—	270	2.34	800	0.13	18.83

Sea color 2.5 | Transparency 19m.(42°) | Wind wave WSW/4 | Swell WSW/2 | Wind WSW/4 | Cloud Cu/10 | Weather ●°

Vertical haul ("maru-toku" net) : 0~50m.(18°)

Horizontal tow ("maur-chi" net) : 10 minutes at abcut 2 knots

St. 36 Date Aug. 28, 1955 Time 18 : 25—19 : 35 Lat. 40°15′.6 N Long. 133°52′.5 E Depth >1,800m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_2 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	24.9	18.71	—	—	8.23						0	24.9	18.71
11	25.89	18.72	4.63	94.8	8.23						10	25.89	18.72
25	11.63	18.72	5.82	93.0	8.17						25	11.63	18.72
48	5.98	18.85	7.65	109.1	8.11						50	5.98	18.85
71	4.05	18.83	5.83	79.4	7.91						75	3.88	18.83
124*	1.80	(18.73)	5.91	76.3	7.81						100	2.82	18.83
173*	0.94	18.83	5.52	69.8	7.76						150	1.34	18.83
220*	0.57	(18.67)	5.38	67.3	7.72						200	0.73	18.83
298*	0.35	(18.76)	5.66	70.3	7.72						300	0.35	18.83
676*	0.10	18.84	6.16	63.8	7.67						400	0.28	18.83
864*	0.08	18.84	5.23	64.8	7.68						600	0.15	18.82
1048*	0.13	18.85	5.22	64.7	7.68						800	0.09	18.84
1232*	0.12	18.86	5.20	64.4	7.68						1,000	0.12	18.85

Sea color 2.5 | Transparency 15m.(34°) | Wind wave ESE/4 | Swell ESE/2 | Wind ESE/4 | Cloud Sc/10 | Weather ●¹

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_2 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Interpolated Depth m	Interpolated Temp. °C.	Interpolated Cl ‰

(Observed: Depth through Alkalinity; Interpolated: Depth, Temp., Cl)

Vertical haul ("maru-toku" net) : 0～50m.(16°)
Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 37 Date Aug. 28, 1955 Time 22 : 30—23 : 48 Lat. 40°30′.0 N Long. 134°18′.0 E Depth 900m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_2 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkalinity	Depth m	Temp. °C.	Cl ‰
0	24.6	18.58	—	—	8.23						0	24.6	18.58
5	25.68	18.61	4.60	93.8	8.15						10	12.35	18.61
11	9.69	—	8.10	—	8.22						25	3.64	18.83
25	3.64	18.83	7.99	107.9	8.11						50	1.43	18.85
50	1.43	18.85	6.80	87.0	7.92						75	1.36	18.86
80	1.35	18.86	6.84	87.7	7.87						100	0.85	18.85
103	0.78	18.85	6.86	86.4	7.88						150	0.58	18.85
156*	0.55	18.85	6.87	86.0	7.88						200	0.47	18.84
201*	0.47	18.84	6.68	83.5	7.83						300	0.33	18.84
459*	0.10	18.85	5.92	73.3	7.79						400	0.18	18.85
522*	0.16	18.86	5.63	69.8	7.69						600	0.10	18.85
543*	0.11	18.85	5.68	70.4	7.69								
738*	0.09	18.86	5.44	67.3	7.69								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	SE/4	SE/2	SE/3	Nb/10	●2

Vertical haul ("maru-toku" net) : 0～50m.(17°)
Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

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St. 38 Date Aug. 29, 1955 Time 08 : 08—09 : 29 Lat. 40°56′.0 N Long. 132°55′.5 E Depth 3,000m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_2 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkalinity	Depth m	Temp. °C.	Cl ‰
0	25.0	18.50	—	—	8.24	0	716	0	1	2.37	0	25.0	18.50
5	24.93	18.54	6.96	139.7	8.19	4.9	766	0.5	2	2.43	10	13.66	18.74
7	16.58	18.73	5.09	89.3	8.13	4.9	740	0.2	1	2.43	25	7.51	18.81
12	11.72	18.74	8.42	134.8	8.13	26.1	772	0.2	1	2.41	50	2.26	19.06
26	7.19	18.82	8.61	125.9	8.08	27.6	889	0.4	0	2.41	75	1.24	18.87
50	2.26	19.06	7.72	101.2	7.93	45.6	1,024	—	124	2.42	100	0.88	18.85
68	1.55	18.86	6.92	88.9	7.89	54.0	1,041	1.1	148	2.47	150	0.55	18.84
73	1.27	18.88	6.72	85.7	7.88	45.2	963	1.7	122	2.41	200	0.44	18.84
118*	0.62	18.84	5.27	66.1	7.84	49.1	1,023	0.9	145	2.45	300	0.29	18.83
207*	0.43	18.84	5.99	74.8	7.79	56.4	1,209	0.9	213	2.38	400	0.25	18.83
292*	0.29	18.83	5.71	71.0	7.74	57.2	1,315	0.7	229	2.49	600	0.16	18.84
778*	0.09	18.85	5.35	66.2	7.69	66.8	1,586	—	334	2.45	800	0.09	18.85
970*	0.10	18.86	6.90	85.4	7.69	63.3	1,647	0.6	316	2.45	1,000	0.10	18.88
1,153*	0.12	18.96	5.30	65.7	7.69	64.2	1,730	0.7	288	2.49			
1,367*	0.07	18.86	5.49	68.0	7.69	64.8	1,754	0.6	288	2.48			

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
3	17m.(42°)	S/5	S/2	S/6	St/10	●1

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰

Vertical haul ("maru-toku" net) : 0∼50m.(29°)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 39 Date Aug, 30, 1955 Time 05 : 10—05 : 30 Lat. 41°33′.7 N Long. 132°00′.0 E Depth >3,000 m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	23.0	18.65	—	—	8.14	—	130	0.9	0	2.30	0	23.0	18.65
31	4.98	18.79	8.31	115.5	8.14	2.2	127	0.5	0	2.32	10	17.18	18.70
42	3.28	18.80	7.20	96.6	7.99	2.2	215	—	90	2.33	25	8.47	18.76
61	1.82	18.73	7.01	90.4	7.93	4.1	354	2.1	167	2.30	50	2.67	18.77
81	1.20	18.81	6.87	87.4	7.89	13.3	406	2.2	277	2.30	75	1.37	18.79
100	0.74	18.81	6.86	86.3	7.89	13.8	431	2.5	174	2.33	100	0.74	18.81

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	N/6	N/3	N/7	Nb/10	●°

St. 40 Date Aug. 30, 1955 Time 12 : 30—14 : 15 Lat. 41°42′.0 N Long. 133°00′.0 E Depth >3,000m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	17.3	18.55	—	—	8.14						0	17.3	18.55
10	17.75	18.56	5.80	103.5	8.14						10	17.75	18.56
15	14.41	18.61	6.62	111.3	8.14						25	5.72	18.83
20	7.72	18.76	8.15	120.4	8.14						50	1.80	18.85
25	5.72	18.83	8.49	120.2	8.07						75	1.44	18.86
50	1.80	18.85	6.90	89.3	7.92						100	1.04	18.85
75	1.44	18.86	6.70	85.9	7.83						150	0.78	18.85
100	1.04	18.85	6.59	83.6	7.83						200	0.53	18.85
165*	0.70	18.85	6.49	81.6	7.83						300	0.26	18.84
193*	0.55	18.85	6.18	77.4	7.79						400	0.18	18.85
304*	0.25	18.84	5.85	72.7	7.73						600	0.14	18.86
454*	0.14	18.85	5.41	67.0	7.69						800	0.11	18.88
647*	0.14	18.86	5.29	65.7	7.69						1,000	0.15	18.94
844*	0.10	18.89	5.23	64.8	7.68						1,500	0.15	18.89
1,043*	0.16	18.96	5.28	65.6	7.68						2,000	0.13	18.86
1,501*	0.15	18.89	5.28	65.6	7.63						2,500	0.20	18.86
2,004	0.13	18.86	5.31	65.7	7.62								
2,507*	0.20	18.86	4.97	61.7	7.63								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
3	—	SSE/5	NE/2	SSE/4	Nb/10	◎

Vertical haul ("maru-toku" net) : 0∼50m.(∅ °)

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 41 Date Aug. 30, 1955 Time 21 : 00—22 : 23 Lat. 41°37.′0N Long. 134°00′.0 E Depth >3,000m.

	Observed										Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C	Cl ‰
0	17.3	18.67	—	—	8.08	3.2	799	0.1	1	2.33	0	17.3	18.67
10	16.90	18.67	6.11	107.4	8.08	2.4	631	0.1	0	2.39	10	16.90	18.67
16	17.43	18.68	5.93	105.2	8.08	—	—	—	—	—	25	6.63	18.80
19	7.86	18.80	8.56	128.3	8.07	—	—	—	—	—	50	3.07	18.85
23	6.95	18.80	5.64	82.0	8.07	23.3	627	0.1	0	—	75	1.74	18.86
45	3.44	18.85	7.73	103.9	7.96	29.8	747	3.5	66	2.39	100	1.22	18.87
65	1.94	18.86	6.97	90.4	7.86	43.2	889	1.8	107	2.38	150	0.83	18.86
109	1.04	18.87	5.63	71.3	7.87	44.0	1,089	—	135	2.45	200	0.63	18.86
145*	0.85	18.86	6.86	86.5	7.85	41.8	1,106	1.1	193	2.39	300	0.35	18.88
189*	0.66	18.86	6.77	85.1	7.85	48.1	1,298	0.7	177	2.41	400	0.20	18.88
247*	0.51	18.86	6.24	78.1	7.77	54.1	1,311	0.6	228	2.41			
281*	0.40	18.89	5.85	72.9	7.67	57.0	1,297	0.5	226	2.45			
333*	0.27	18.87	5.69	70.8	7.67	61.3	1,251	—	263	2.46			
399*	0.20	18.88	5.55	68.9	7.67	62.3	1,411	0.7	252	2.43			
516*	0.13	18.86	5.43	67.3	7.77	64.2	1,482	—	249	2.41			

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
—	—	NW/6	NW/2	NW/6	Nb/10	◎

St. 42	Date	Time	Lat.	Long.	Depth
	Aug. 31, 1955	05 : 30—07 : 05	41°38′ 5N	134°58′.5 E	ca.3,500 m.

Depth m.	Temp. °C.	Cl ‰	O_2 cc/L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C	Cl ‰
0	15.0	18.75	—	—	8.13						0	15.0	18.75
10	15.09	18.75	6.46	110.2	8.12						10	15.09	18.75
15	15.11	18.75	6.45	110.1	8.13						25	14.92	18.75
25	14.92	18.75	6.98	116.8	8.07						50	4.10	18.87
35	12.98	18.77	8.26	135.3	8.12						75	2.12	18.88
40	5.62	18.86	6.89	97.3	8.07						100	1.16	18.87
59	2.73	18.88	8.68	114.8	7.87						150	0.92	18.86
100*	1.16	18.88	6.88	87.6	7.82						200	0.75	18.87
148*	0.92	18.86	7.11	89.8	7.87						300	0.53	18.86
172*	0.86	18.87	6.93	87.6	7.82						400	0.36	18.84
225	0.66	18.87	6.78	85.3	7.82						600	0.18	18.86
488*	0.21	18.83	5.87	72.8	7.72						800	0.16	18.86
639*	0.17	18.87	5.33	66.2	7.67								
811*	—	18.86	5.23	—	7.67								
982*	0.15	18.86	5.24	65.0	7.63								

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
4	—	NE/6	NE/2	NE/7	Nb/10	●°

Horizontal tow ("maru-chi" net) : 10 minutes at about 2 knots

St. 43	Date	Time	Lat.	Long.	Depth
	Aug. 31, 1955	16 : 00—17 : 40	41°38.′3 N	136°01′.0 E	ca.3, 500m.

Observed											Interpolated		
Depth m.	Temp. °C.	Cl ‰	O_2 cc./L	O_2 %	PH*	P_2O_5 γ/L	SiO_2 γ/L	N_2O_3 γ/L	N_2O_5 γ/L	Alkali-nity	Depth m.	Temp. °C.	Cl ‰
0	20.6	18.75	—	—	8.18	2.1	148	1.5	3	2.36	0	20.6	18.75
11	20.37	18.84	5.25	98.2	8.13	4.2	140	0.5	2	2.33	10	20.39	18.83
14	20.65	18.76	5.23	97.9	8.14	—	—	—	—	—	25	6.69	18.84
19	15.79	18.82	7.87	136.0	8.14	—	—	—	—	—	50	2.42	18.85
23	7.14	18.84	8.86	129.4	8.13	8.1	149	0.5	1	2.35	75	1.71	18.86
43	2.68	18.85	7.72	101.9	8.03	16.3	170	0.5	87	2.34	100	1.29	18.86
64	1.89	18.86	6.72	87.1	8.03	14.2	399	1.2	51	2.35	150	0.87	18.86
102*	1.26	18.86	6.98	88.9	7.94	15.5	329	2.4	59	2.34	200	(0.70)	18.86
143	0.91	18.86	6.98	88.2	7.94	20.5	456	7.5	58	2.37	300	(0.57)	(18.86)
183*	0.72	18.86	6.84	85.8	7.89	—	424	0.7	90	2.35	400	(0.44)	(18.86)
226	—	88.86	6.12	—	7.79	38.6	517	0.7	99	2.37	600	(0.19)	(18.87)
629*	0.15	18.87	5.36	66.3	7.74	—	980	—	113	2.38	800	0.13	18.87
782*	0.13	18.87	5.24	64.8	7.69	38.7	1,063	1.8	112	2.38	1,000	0.10	18.88
977*	0.11	18.88	5.13	63.5	7.69	—	1,190	—	161	2.40			
1,168*	0.05	18.88	5.92	73.2	7.69	44.9	1,175	0.6	154	2.40			

Sea color	Transparency	Wind wave	Swell	Wind	Cloud	Weather
4	—	N/6	N/3	N/7	Nb/10	⊗°

Vertical haul ("maru-toku" net) 0~50m.(0°)

Horizontal tow("maru-chi" net) : 10 minutes at about 2 knots

1955年夏季北部日本海に於ける微量栄養成分の分布について

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On Distributions of Minute Nutrients in the North Japan Sea; in the Close of August, 1955

by

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Abstract

In the close of August, 1955, the investigation of the North Japan Sea was carried out by Sôyô-maru. We were alloted a part of determinations of minute nutrients (Silicate-Si, Phosphate P, Nitrite N, Nitrate-N), hydrogen-ion concentration and alkalinity. From each distribution of these factors, a presumption on the structure of water-mass system was made as shown in Fig.7 schematically.

A note on the temperature correction of hydrogen-ion concentration was added, and it was emphsized that this correction is indispensable to obtain precise pH value and to calculate correct total CO_2.

I. 緒　　言

日本海の沖合及び深層の水系構造については，戦前行われた二三の調査に基く考察があるに過ぎない。しかも対馬暖流の各分枝，北方沖合寒冷水の流動・消長の把握は，沿岸の海況ひいては沿岸漁業の豊凶を支配する要因の分析に重大な意義を有するものである。従つて沖合・深層の探査を希求する声が高い。1956年夏蒼鷹丸による北部日本海沖合調査が実現され，われわれは日本海区水研と協力して水系分析上重要な決め手となる各種栄養塩類の測定を行い，その分析様相から沖合水系の構造に吟味を加えた。

II. 方　　法

第1図に示す観測点中 31・33・35・39・41 及び 43 の計7点で， 0・10・25・50・75・100・150・200・300・400・600・800・1000 m の13層（水深・天候の関係で採水層が浅部に限られたところもある）より採水，クロロフオルムを添加固定し，分析測定は蒼鷹丸の東京帰着を待ちこれを行つた。

測定項目及びその方法は次の通りである。



Fig-1 ; The map showing stations at which water Samplings were made.

1) 硅酸態—硅素：DIENERT-WANDENBLUCKE の方法を改良した ROBINSON-THOMPSON の方法。
2) 燐酸態—燐：DENIGES-ATKINS の方法。
3) 亜硝酸態—窒素：GRIESS-ROMIJIN 試薬による方法。
4) 硝酸態—窒素：HARVEY の方法による還元ストリキニンを使用する方法。
5) pH：比色法を用い温度補正を行う。(pH は全点，測定)。
6) アルカリニテイ：町田の混合指示薬(methyl-orange 及び aniline-blue の混合液)を用いて滴定を行う。

尚 pH の温度補正に関しては後述する。

Ⅲ. 測定結果

(1) 硅酸態—硅素

対馬暖流の各分枝の影響下にあると思われる St-31・35 では，表面で 150 γ/L 程度であつて，100〜150 m 層に飛躍層があり，300〜700 γ/L 程度と急増する，200 m 以深では漸増して 800〜1,200 γ/L に及ぶ。

St-33・38・41 では 10〜75 m 層といつた極く表層に飛躍層があり，前記各点よりも浅部に移行していることが第2図の断面図からも察知せられよう。

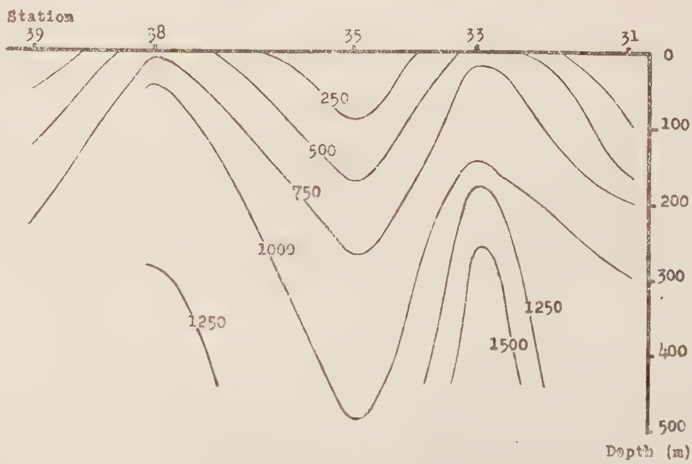


Fig-1; Sectional distribution of silicate-Si, along the NW-line from Noto Peninsular. γ/L

(2) 燐酸態—燐

硅酸態—硅素とその分布傾向は類似している。即ち暖流系水の影響を被つていると思われる St-31 では，150 m 層まで 10 γ/L 以下であるが，150〜200 m 層に顕

著な飛躍層があり 200 m 以深では 30～50 γ/L の多きに及ぶ。

対馬海峡より対馬暖流の分枝として沖合を北東流する東朝鮮海流による結果と思われるが St-35 では 100 m 層までは 5 γ/L という貧栄養の水層に覆われており，100 m に顕著な飛躍層が発達して 20 γ/L に増加，下層よりの北方系富栄養水の侵透乃至は日本海深部固有水の発達を示すものの如く，漸増して 200 m で 40 γ/L，400 m で 50 γ/L，900 m では 68 γ/L となる。

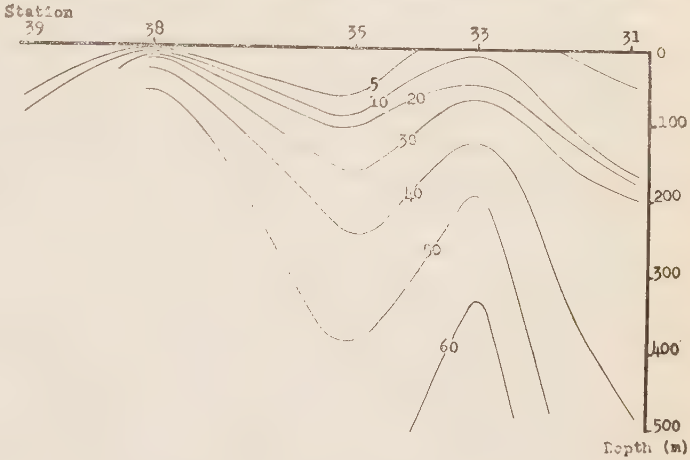


Fig-3: Sectional distribution of phosphate-P, along the NW-line from Noto Peninsular (γ/L).

これに対し大和堆附近で占められた St-33 に於ては，海底隆起に伴う底層の寒冷水の上昇を示すものか表層に極めて薄い暖流系貧栄養水の張出しが認められるだけであつて，表面下 50 m で 20 γ/L の燐酸が認められ，80 m では，45 γ/L,以後漸増して 500 m で65 γ/L，700 m で γ/L を越す。

略々同様の垂直分布の傾向が St-38 でも見られるが，表層での急増の様相が更に一層顕著であり 200 m以深では St-33 と同様となる。

St-41 では St-33・38 に類似，St-43 では奥羽沖合で合流した各暖流分枝の北上流域である故か躍層が 100 以深になるのも興味深い。

（3） 硝酸態一窒素及び亜硝酸態一窒素

硝酸態一窒素は表面に極めて乏しく，殆んど認めることが出来ないが， 50 m 深附近から急増する傾向にある。また St-31・33・35 等に比べ高緯度に位置した St-38・39・41・43 では飛躍層が可成り浅部に存在し，前者が大体 50～100 m 深に飛躍層が存するに対し，後者では 20～50 m 層にそれが認められる。 St-31 より St-39 に至る線に沿つた断面図（第 4 図）に見られる様に，前記硅酸・燐酸の分布傾向と類似している。

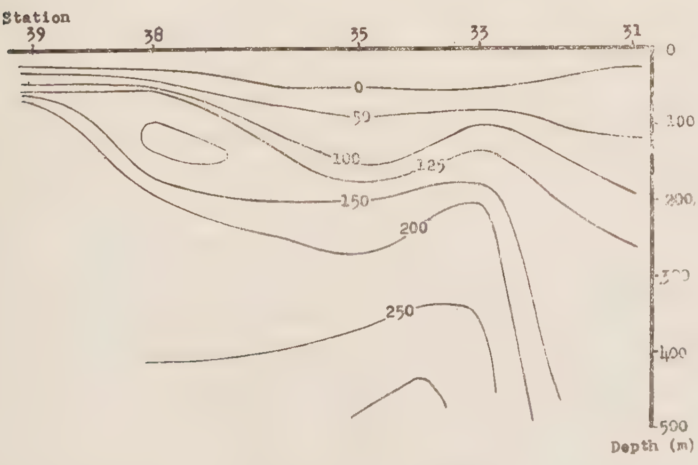


Fig-4; Sectional distribution of Nitrato-N, along the NW-line from Noto Peninsular (γ/L).

亜硝酸態一窒素は全般に極めて僅少であり，定量すること自体が非常に困難であつたし，元来極めて不安定で微妙な変化を遂げる物質でもあるので，水系構造の推測或いは海洋中の N-サイクル の問題の手掛りに用いるが如き立入つた論議は避けたいと思う。しかし 200m 以浅層について極大層を観察してみると前述の St-33・38 では浅部に，St-31・35・43等ではやや深部に認められることを指摘し度い。

（4） pH 及び全炭酸

pH 値は後述する様な理由と方法とにより，20°C に於ける値

(pH_{20}) を求めてこの値を検討した。

先ず第一に留意すべきことは，前述の栄養塩類についても言えることであるが，太平洋黒潮系水に比較して飛躍層が極めて浅部に存在することである。即ち黒潮系水で pH が 8.0 以下となるのは 300〜400 m 以深の場合が多いのに対し，本水域では 50〜100 m の深度で既に pH 8.0 以下となる。これは太平洋親潮水域の pH 分布と類似している。

表層部では pH 8.15〜8.25 の値を示すが，深度を増すと急激に pH は減少してゆき 200m を越すと pH 7.70〜7.75 と安定した値を示す様になる。

この表面より 300 m 深位までの pH の垂直分布の模様から第 1 表の如く観測点を水域別にまとめ上げることが出来る。

Table 1 ; Station groups divided by the type of vertical distribution of hydrogen-ion concentration.

No.	Station	Region
①	St. 29, 30.	Tsushima Current region.
②	St. 31, 32, (33).	Region affected by Tsushima Current.
③	St. (34), 35, 36.	Eastern Korea Current region.
④	St. 37, 38, 39, 40, 41, 42.	Region affected by northern cold water.
⑤	St. 43.	Confluence region of branches of Tsushima Current.

① にあつては飛躍層は 100〜200 m の深部であり， ② では 50〜150 m の比較的広い層に亘る。② との中間型に St-33・34 を含みながら， ③ では飛躍層の範囲深度が比較的狭く且 75〜100 m とやや深部にある。④ では第 1 躍層が 50 m 以浅に現われ不明瞭ながら第 2 躍層が 100〜200 m 附近に現われているもので， 中層水的水系の存在を暗示する。

⑤ に至ると ① と類似の形態をとる様になる。St-31 〜 St-39 に至る線に沿つての断面は第 5 図に示す通りであり，上記栄養塩類の分布断面と類似の様相を示す。

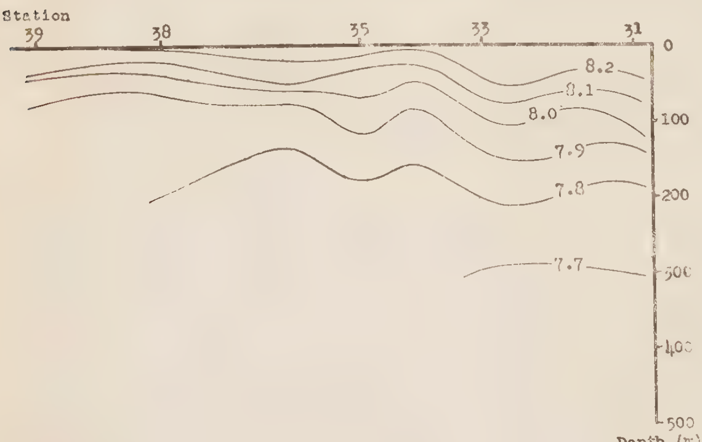


Fig-5; Sectional distribution of Hydrogen-ion concentration, along the NW-line from Noto Peninsular.

Titration alkalinity は表層で 2.30—2.40 meq/L, 深層に及ぶに従い僅かに漸増して2.35—2.45 meq/L となる。 また硼酸の存在を考慮して Chlorinity, pH 及び温度に基いて補正し，所謂 Carbonate alkalinity を求めると表層で 2.20—2.30 meq/L, 深層で 2.30—2.40 meq/L の値を得た。

pH_{20} 及び Carbonate alkalinity から全炭酸量を算出し，能登 NW 沖線の断面図を描くと第 6 図の如くなる。即ち表層では 2.00 mmol/L (44.8 cc/L), 深度を増すと漸次増加 300 m 深で 2.25—2.30 mmol/L (50.4—51.5 cc/L) の値が示される。また St-31・35 では分布傾度が緩く，St-3 3・38 等では傾度が大きい。

Ⅳ. 考察—水系構造の推定

以上の事柄を綜合して調査水域に於ける水系構造を模式的に第 7 図の如く描くことが出来るであろう。即ち

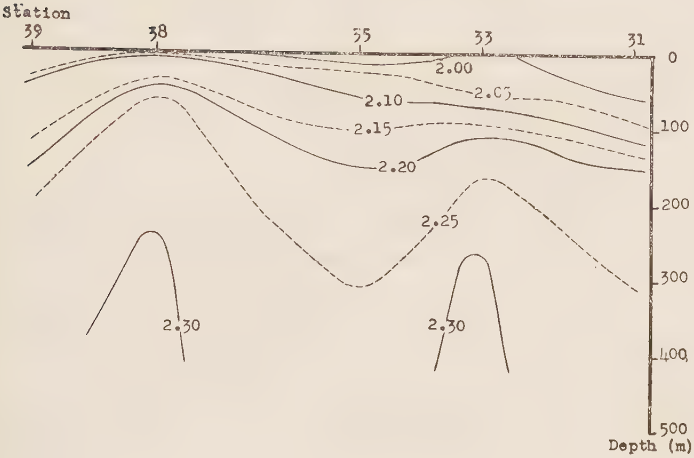


Fig-6; Sectional distribution of total CO_2, along the NW-line from Noto Peninsula. (mmol/L)

本土沿岸に沿い北上する対馬本流は，能登半島の沖合に張出して薄く表層を覆つている。又対馬海峡か朝鮮に沿い北上，日本海中央部を北東流して来た東朝鮮海流が，約100mの厚みを有しつつ，St-35をその流域に含み北上している。この対馬暖流の二分枝に狭まれるSt-33・34附近には反時計廻りの渦流が形成せられているであろうし，またこの水域は大和堆上にあたり海底地形も手伝つて顕著な湧昇域を形成していると思われる。従つて相当浅部から栄養塩類に富んだ水の発達が認められるのであろう。

St-38附近では東朝鮮海流の張出しが，極く表層ながら反時計廻りの渦流を形成，北方寒冷水の潜入・湧昇をもたらしているものであろう。

対馬本流・東鮮流の二分枝はその後奥羽沖で合流するかして，更に北上を続けるものであろう。St-43では栄養塩・pH等の垂直分布型が，むしろ低緯度暖流域の点に於けるそれと類似するのは，暖流系統の水系下に潜入し渦流・海底地形等により湧昇をきたした北方深層水の補流的な下降流が，暖流系水により行われている結果と解釈出来ぬものであろうか。

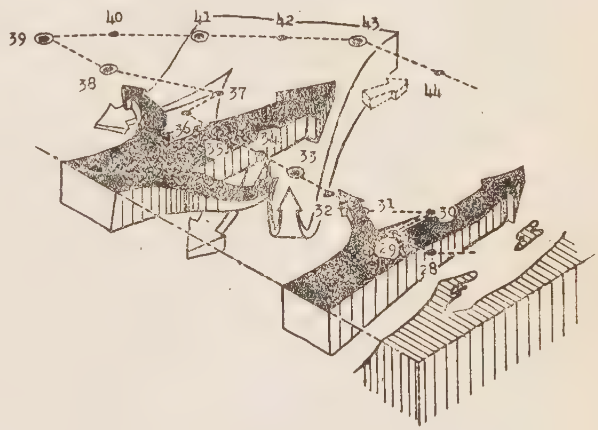


Fig-7; Schematical illustration of water-mass system in North Japan Sea.

Ⅴ. pH の温度補正に関して

前掲の如く海洋水のpHの水平・垂直分布を知ることは，水温・塩分の分布或いは栄養塩類のそれを求めることと同様に，水系・海流の探査上大切なことである。のみならず海洋中に於ける炭酸の収支の問題，ひいては海洋中に於ける生産の問題を論ずる上に，全炭酸量を求めるにはpH及びalkalinityより算出せねばならず，また全炭酸の指標的な値としてpHを用いる場合をも考えると，是非ともその正確な測定が期待されねばなない。

従来海洋観測ではpHの測定に指示薬を用いる比色法が，簡便でもあり広く適用され一般化しているが，本法では(1)塩誤差・(2)蛋白誤差・(3)酸誤差・(4)温度誤差等が附随する。第1の塩誤差はMcClendonのbuffer solutionを使用することで除去出来，現行の標準列もこれを使用している。第2・第3の誤差はさほどでないにしろ，従来最も重要でありながら等閑に附されていたのは第4の温度補正である。

即ち温度が異つて来れば標準列のbuffer solution自身及び海水の保有するpHが異つて来るし，指示薬の解離度も変化するものであるから，是非とも補正を行わねばならない。このためには炭酸ガスの得失がない場合につきBuch (1929)が理論的に与えた式

$$pH_{tw}=pH_{tb}+\alpha(t_b-t_w)+\beta(t'_w-t_w)$$

を用いて簡単に行うことが出来るのである。上式中に用いられた各記号は

pH_{tw} ： 水温 t_w°C にに於ける試水の pH 値

pH_{tb} ： 比色時の標準列の buffer solution の温度 t_b°C に於て buffer solution が示すべき pH

t'_w ： 比色時の試水の温度（°C）

α ： 指示薬の解離度の温度による変化率（温度係数）

β ： 海水の温度係数と α との差

α・β は何れも BUCH により実験的に求められた常数である。

先ず pH_{tb} を求めるには buffer solution の温度係数を知らねばならぬが，McCLENDON の buffer solution のそれは直接求められていない。海水の pH 測定に用いられる buffer solution 中で，S RENSEN の Borax-HCl buffer solution につき WALBUM（1920）が温度による pH の変化を実測し，BUCH（1929）がこれを利用して内・外挿の更正表を作つた。COOPER（1933）はこの更正表は McCLENDON の buffer solution にも適用し得るものであろうと指摘している。従つてわれわれもこの BUCH の更正表を利用し pH_{tb} を求めた。

また上式中右辺の第2・第3の項によつて示される補正に関しては，海水は通常 pH 7.6—8.4 の範囲にあり cresol-red を指示薬とすることにより測定可能であり，cresol-red の温度係数 α 及び β は BUCH により0.0053, 0.006 と夫々実験的に求められている。

今次の観測にはこの点に留意し，pH の現場測定には次の如き方法をとつた。即ち試水は 100 cc 容酸素瓶に酸素定量の際の要領に同じく静かにとり，5％昇汞液3滴を加え固定密栓し，3～5時間放置後比色管に試水をとり，常の如く比色測定した。この際気温（buffer solution の温度 t_b と見なす）及び試水温度（t'_w）を棒状短型寒暖計で読みとり，pH の読み取り値に温度補正を加えた。

われわれの遭遇した最も普通の例を第2表に示したが，低温の深層水の現場の pH（pH_{tw}）は，船上で読み

Table 2 : An comparison between the raw value of pH and pH_{tw} (pH in situ), pH_{20} (pH at 20°C) : and values of total CO_2 calculated from these pH values and alkalinity.
(Cl′＝19.00‰, Alkalinity＝2.35meq/L, t_b＝29.0°C)

	pH	Temp. (°C)	Factor for calc. ΣCO_2	Total CO_2	
				mmol/L	cc/L
pH_{obs}	7.60	t_w = 0	1.01	2.37	53.2
		t'_w = 27.0			
pH_{tw}	7.90	t_w = 0	0.98	2.30	51.5
pH_{20}	7.65	20.0			

$$\text{Factor for calculation of total } CO_2 = \frac{1+(K_1'/a_{H^\cdot})+(\alpha_S \cdot a_{H^\cdot})/(K_1' \cdot a_{H_2O} \cdot \alpha_0)}{1+(2K_2'/a_{H^\cdot})}$$

取られた生の値（pH_{obs}）より遥かにアルカリ性であることが首肯出来よう。pH は水温・塩分と共に生物の重要な環境因子であつて，この点にも留意すべきではあるが，更に炭酸の分布・収支の問題を論ずる場合には，pH_{tw} を用いるより炭酸の得失がなくして或る特定の温度になつた場合の各 pH 値の相互比較を行い，炭酸分布の間接的指標となすべきである。これには McCLENDON の buffer solution が正確に目盛られた温度 20°C を以て換算基準温度とするのが妥当であろう。

斉一の温度に換算した pH 値の相互比較を行うのでなければ，PH 値が温度により変化する以上無意味なことになろう。また pH と alkalinity とから全炭酸は次式

$$\text{Total } CO_2 = \text{Carbonate alkalinity} \times \frac{1+(K_1'/a_{H^\cdot})+(\alpha_S \cdot a_{H^\cdot})/(K_1' \cdot a_{H_2O} \cdot \alpha_0)}{1+2K_2'/a_{H^\cdot})}$$

を以て算出出来るのであるが，BUCH（1951）により carbonate alkalinity に乗ずべき係数は各 pH・水温・塩分につき表として計算されているので，簡単に行うことが出来る。

以上式を用いて第2表中の各 pH 値をから全炭酸量を算出して同表中に示した，生の読取値（pH_{obs}）を現場の pH（pH_{tw}）の如く考えると，全炭酸量は絶対値の上では正当な値と大差がない様に見えるが，通常海洋水

中の全炭酸量が 50 cc/L 前後で変動するものであることを考えれば，この際の誤差は極めて大きいものであることが判るであろう。

更に正確には深層であれば極めて強い水圧の結果，現場の pH は上昇することが Buch and Gripenberg (1932) により指摘されているし，前述の様に McClendon の buffer solution については温度計数が求められておらず，Sorensen の buffer solution のそれを便宜的に利用しているのであるから，直接これを求むべきである。

従来唯機械的な操作に了っている pH の測定も，この点より正確なる測定及び温度補正の必要性が痛感されるのであろう

日水研下村部長，蒼鷹丸乗組員の御尽力を心から感謝したい。

VI. 要　　約

1955年 8 月に行われた蒼鷹丸による北部日本海沖合調査に参加して，栄養塩類の定量を行つた。測定項目は次の通りである。

(1) Silicate-Si, (2) Phosphate-P, (3) Nitrite-N, (4) Nitrate-N, (5) pH, (6) Alkalinity

こらの測定結果から，各栄養塩類の分布を述べ水系構造に関する推定的考察を行つた。また pH については従来の機械的な操作に了る測定では pH の真の意味を把握することは出来ず，温度補正の必要であることを指摘した。

VII. 参 考 文 献

Buch, K. (1929) ; On the determination of pH in sea water at different temperature. Jour. du Cons. vol. 3, pp. 267-280.

朝鮮総督府水産試験場 (1933) ; 昭和 8 年海洋観測成績，海洋調査要報第 8 号

福岡県水産試験場 (1953) ; 東対馬水道海洋観測資料（大正 2 年 9 月〜昭和27年 2 月）

Fleming, J. A. ; H. U. Sverdrup ; C. C. Ennis ; S. L. Seaton ; W. C. Hendrix (1945) ; Observations and results in physical oceanography, Scinent. Res. of Cruise VII of 'Carnegie' during 1928- 1929 under comm. of Cap. J. P. Ault, oceanogr. I-B.

Harvey, H. W. (1955) ; The chemistry and fertility of sea waters, Cambridge Univ. Press.

Machida, Y. (1953) ; Some notes on the method of alkalinity determination. Bull. of the Japanese Soc. of Sci. Fish., Vol. 19, No. 5, pp. 703-709.

宮崎　道夫 (1953) ; 日本海の水塊について（海況予想の研究—II），北水研報告，No. 7, pp. 1〜65.

三宅　泰雄 (1948) ; 水質分析，理化集報 6，小山書店刊。

日本海区水産研究所 (1951) ; 昭和26年夏対馬海流域一斉観測結果。

同　　　上 (1952) ; 昭和27年夏対馬海流域一斉観測結果。

日本海洋学会 (1955) ; 海洋観測指針。

中井甚二郎 (1933) ; 本場海洋調査部の採集している水素イオン濃度測定法並栄養塩類定量法，朝鮮総督府水産試験場海洋調査要報，5・6 号 pp. 100〜103.

下村　敏正 (1954) ; 海況による漁況予報。岩波 "科学"，24巻10号 pp. 498〜500

水産試験場 (1934) ; 海洋調査要報，54号

須田　晥次 (1932) ; 日本海の底層水について海洋時報，4 巻 1 号 pp. 221〜240

Sverdrup, H. U. (1942) ; The oceans, their physics, chemistry and general biology, Printice-Hall, Inc.

高橋　孝吉 (1934) ; 犬吠崎東方海区に於ける水素イオン濃度の横断観測，水産学会報，6巻 1号 pp. 26〜37

田口　竜雄 (1932) ; 日本海北部の海況予察，海洋時報，4 巻 1 号，pp. 275〜278

宇田　道隆 (1934) ; 日本海及其の隣接海区の海況（昭和 7 年 5・6 月連絡施行日本海第一次一斉海洋調査報告），水産試験場報告，5 号 pp. 57〜190

同　　　上 (1934) ; 日本海・黄海・オホーツク海の平均各月海況（連絡試験調査），同上5号 pp. 191〜236

吉村　寿人 (1954) ; pH の理論と測定法。丸善刊

Planktological Study on the Warm Tsushima Current Regions - IV

Plankton Properties and their Relation to Oceanographic Conditions of the Offshore Regions of the Japan Sea in the Summer of 1955.

by

Toshimasa SHIMOMURA

1. Introduction

The present studies are based on materials collected during the oceanographical observation of those waters conducted over the period August 13~September 1, 1955 on board the "Sôyô Maru", research vessel of Fisheries Agency of Japan. Position of the stations are shown in figure 1. The main purpose of the studies is to get the figure of distribution of macroplankton communities in upper layers of those areas which are certainly bounded by particularities of the water-system, especially of the



Fig. 1 The positions of stations.

Mark o indicates the station where the 'marutoku' net was hauled and mark • that the ordinary oceanographical observation was made alone, without net-haul because of seas.

Tsushima Current (warm) and the offshore colder current regions (the Iiman Current regions).

Method of collecting plankton : Plankton was collected by vertical haul with the "maru-toku" net - B, which measures 45 cm. in mouth diameter, 80 cm. in length along the side and is made of synthetic-resin-processed silk grit gauze 54=54 XXX (aperture 0.33 mm.). The net was lowered to the point where the submerged length of the wire reaches 50m., and then hauled up to the surface. The inclination of the wire varied at different stations (0°-45° ; generally below 20°), as given in the Appended Table put at the end of this thesis.

Measuring the settling volume : Since the main purpose of this investigation was to know the general feature of plankton distribution, no attempt was made to take the count of plankton organisms except for several species such as *Calanus cristatus*, *Parathemisto oblivia* and the like. So that the settling volume of the catch was measured and used as an index of the abundance of plankton. The whole catch at each station (i. e. zooplankton and phytoplankton not segregated) was washed in the 50 cc. measuring cylinder graduated every 0.1 cc., and the volume was read after being left undisturbed for 24 hours. But the identification of specific composition of plankton was carried out at each station.

2. Plankton

Number of species : Number of total species identified are more than 130, comprising more than 81 animal and 46 plant species. Figure 2 shows the number of species at each station and table 1 the number of species belonging to various classificatory groups throughout the whole area under study. Copepoda account for one half of animal species. The majority of plant species belong to Dinoflagellata or Bacillariales. More Dinoflagellata species belong to gen. *Ceratium* than to any other genus. Mention should be made to the fact that at any station more Dinoflagellata species occur in phytoplankton than the species of gen. *Chaetoceros* or gen. *Rhizosolenia*, as the author reported previously (1954).

Table 1. Number of species

Zooplankton	>81	Phytoplankton	46
Protozoa	6	*Cyanophyceae*	1
Coelenterata	4	*Dinoflagellata*	26
Chaetognatha	>4	*Bacillariales*	19
Crustaceae	>45	*Rhizosolenia*	7
Copepoda	>38	*Chaetoceros*	6
Gymnoplea	>22	*Others*	6
Podoplea	16		
Phyllopoda	4		
Ostracoda	1		
Others	2		
Mollusca	3		
Tunicata	6		
Larvae & Pisces eggs	13		

Number of the total species, (i. e. including zooplankton and phytoplankton) varies from station to station between

7 (st. 38 and st. 40) and 43 (st. 26). As is indicated in figure 2, (1) number of the total species, including zooplankton and phytoplankton, varies between 7 and 43, generally 10 and 35, from station to station ; (2) the geographical variation in the number of animal species and plant species coincide, respectively, well with that in the number of the total species ; (3) and the geographical variation in the number of total species is associated with the change in the number of zooplankton species more closely than with it in the number of phytoplankton species.

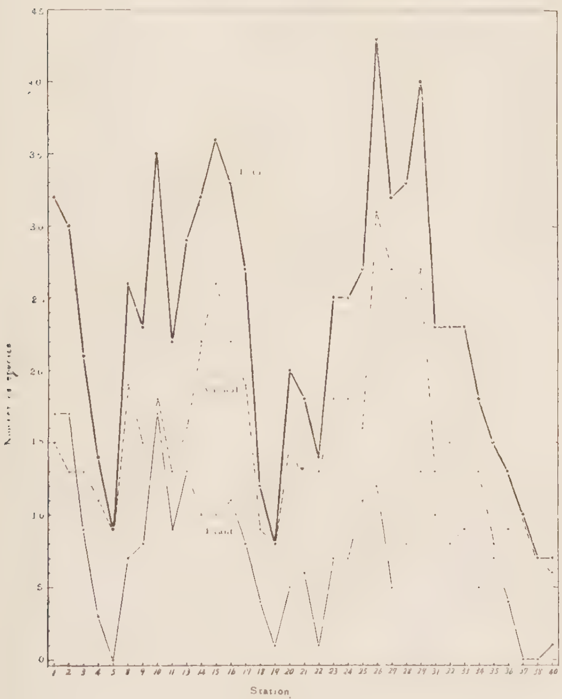


Fig. 2 Number of total, animal, and plant organisms at each station.

At any station, zooplankton is constituted of 6 (st. 40) to 32 species (st. 26), of which more than one half belongs to Copepoda. But the number decreases towards the off-sh ore as described in the next clause.

Number of phytoplankton species to be found at one station varies from 0 (st. 5·37·38) to 16 (st. 1·2 and 10), according to the position of the station. With a few exceptions, these species all belong to Dionflagellata or Bacillariales.

3. Relation between plankten and sea conditions

A) Relation between number of total species and sea conditions

Figure 3 shows the distribution of the number of total species and the path of the Tsushima Current (warm current), during the period of observation. As is clearly indicated in figure 3, the path of the Tsushima Current—many branches as well as the main flow—coincides with the regoin where plankton is composed of 10 to 43 species. In an other region, offshore colder waters north of the Liman Front, the number of species is not more than 10.

Also in the Tsushima Current regions mentioned above, the number of total species is more large in the neritic regions. The warm Tsushima Current in the Japan Sea consists of three main branches as well known (fig. 4). Relation between the number of total species and these three branches is given in the accompanying table. (table 2).

Comparing the number with the distribution of isotherms at 25-metre layer (fig.

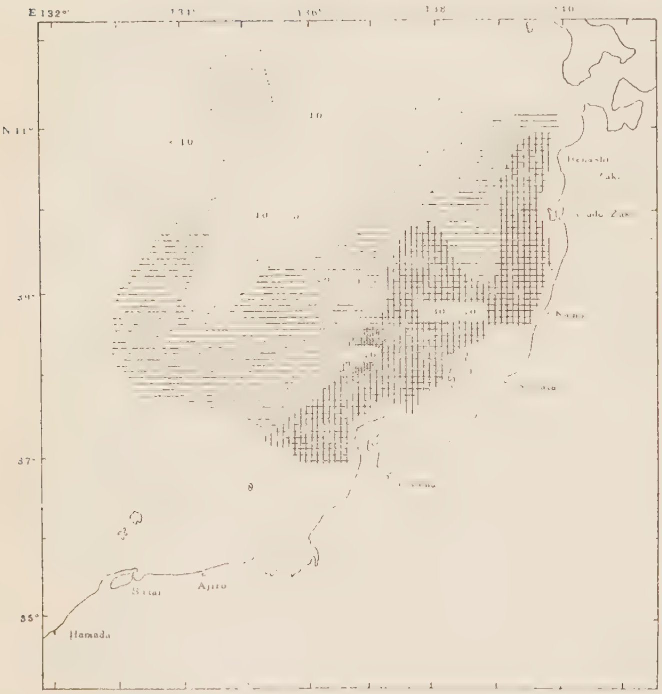


Fig. 3 Geographical distribution of the number of total species.

4), which is the midway of the wire length (50 m.) of plankton net, these two are also closely related each other. This relation is arranged and filled up in the third column of the table mentioned above. Namely, from a thermal point of view, the number of total species is larger in the warmer regions.

A large number of total species more than 30 is due to the increasing in number of species in both zooplankton and phytoplankton, as described before. But looking further (fig. 5), it comes from the

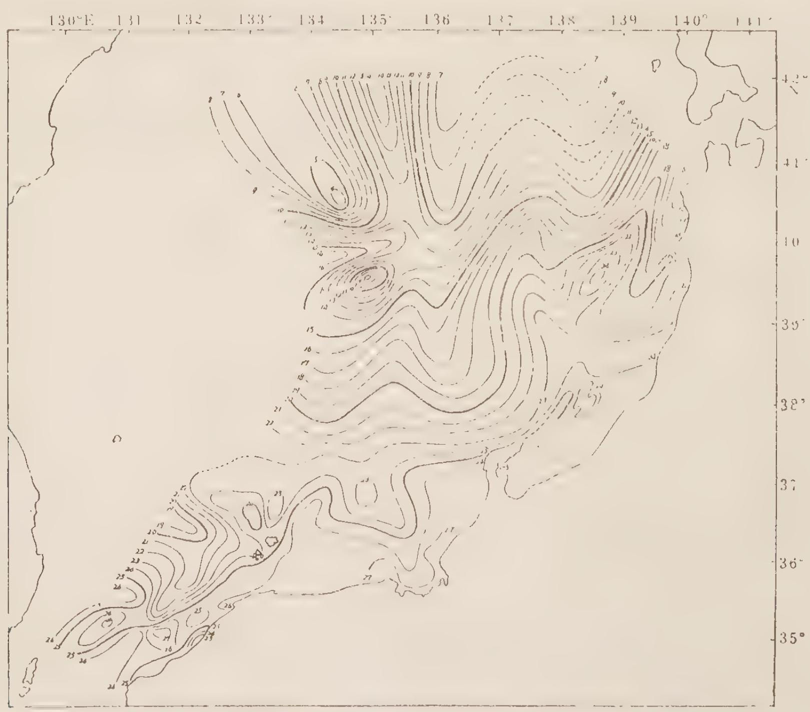


Fig. 4 Geographical distribution of isotherms at 25-meter layer, in August 1955.

Table 2 Relation between water masses and number of total species.

Water masses		Number of total species	W. t. at 25m. layer
The Tsushima Current	The 1st Branch	>30	>20°C.
	The 2nd Branch	20∼30	15°∼20°C.
	The 3rd Branch (including polar front)	10∼20	10°∼15°C.
The Liman Current regions		<10	<10°C.

increasing in the number of Copepoda-species and then Dinoflagellata, *Rhizosolenia*, larval plankton. In other words, such a large number of total species in the neritic regions is attributed to the increasing in number of species in the warmest regions (20°∼25°C. at 25-metre layer) during the period conducted over the present oceanographical observations, and to the simultaneous occurrence of such warmth-loving species and larval forms as follows :— .

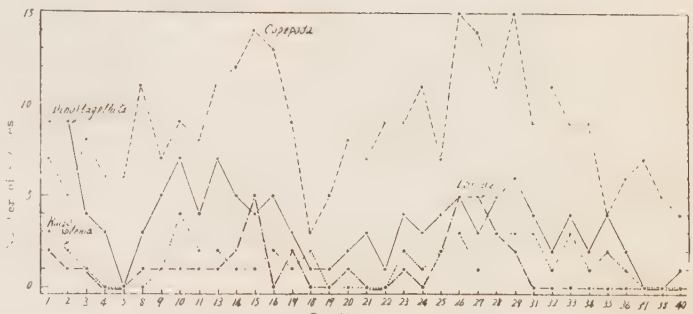


Fig. 5 Number of species in chief component groups at each station. ("Larvae group" does not include *Euphausia* larvae.)

Planktomya Henseni
Creseis acicula
Temora discaudata
Centropages bradyi
Oncaea venusta
Corycaeus lautus
Corycaeus speciosus
Penilia Schmackeri
Cypridina hilgendolfii
Doliolum nationalis
Pyrocystis pseudonoctiluca
gen. *Ceratium*
Rhizosolenia styliformis var. latissima
Rhizosolenia acuminata
Chaetoceros coarctatus
Globigerina bulloides
Tripleen
Acanthometron pellucidum

Based upon the research in the 1st Branch of the Tsushima Current and in somewhat offing beyond it, the author emphasized formerly that the number of total species in the warm Current (the 1st Branch of the Tsushima Current) lies between the less number in the offing (the 2nd Branch) and the larger in the neritic regions (Shimomura, 1954, a, b). The present research was conducted over even in the cold Liman Current regions across the 3rd Branch of the Tsushima Current and the Liman Front (polar front). The data obtained also demonstrate the decreasing in number of total species with being a long way off from Honshu (the mainland of Japan). As no sampling was made in the neritic regions close to Honshu, within the 1st Branch, a detailed description, like the author made formerly, on the geographical distribution of number of total species within the 1st Branch is impossible. But mention should be made to the fact that the area where the number of total species is the most abundant lies constantly 30 nautical miles north of Noto Peninsula as during the observating period September, 1950, July—August, 1951, and June—August, 1952, although the type, mesh and hauling depth of plankton net are different. This large number area comes from the constant existing of the vortex area here, although the vortex conditions differ to some extent from season to season, and year to year. Also in the present observating period, the counter clockwise vortex area lies here, forming a large number area more than 40 species.

B) **Relation between settling volume and the sea conditions** : The settling volume of total plankton organisms, including zooplankton and phytoplankton, varies between 0.7 cc. (st. 1) and 18.0 cc. (st. 19). The geographical distribution of the settling volume is not so simple as that of the number of total species which is large in the neritic regions and decreases in the offing. As given in figure 6, the settling volume in the neritic region (the 1st Branch) is as much as 6 7 cc., and in the 2nd Branch —north off the 1st Branch— it becomes less than 3 cc.. Further, in the 3rd Branch—the mixing region of the Tsushima Current with the Liman Current—the settling volume ranges between 1.5 cc. and 17.0 cc., in other words the fluctuations are also remarkable from station to station. Further northing, in the cold Liman Current regions, it again shows a considerable increase in volume as much as more than 5 cc. and the fluctuations from station to station decrease. It may well be said, as shown formerly (Shimomura, 1954), that the path of the main flow of the Tsushima Current is represented by the region in which settling volume is less (below 3 cc. in this research) than in other regions, and that the neritic region is the region in which the geographical fluctuations of settling volume is least compared with other regions.

The above-mentioned resolves into table 3.

As mentioned previously, the present observation was carried out during the warmest season of the year and then the water temperature at 0-metre layer was over 15°C. throughout the whole waters covered by this study. Especially, since the

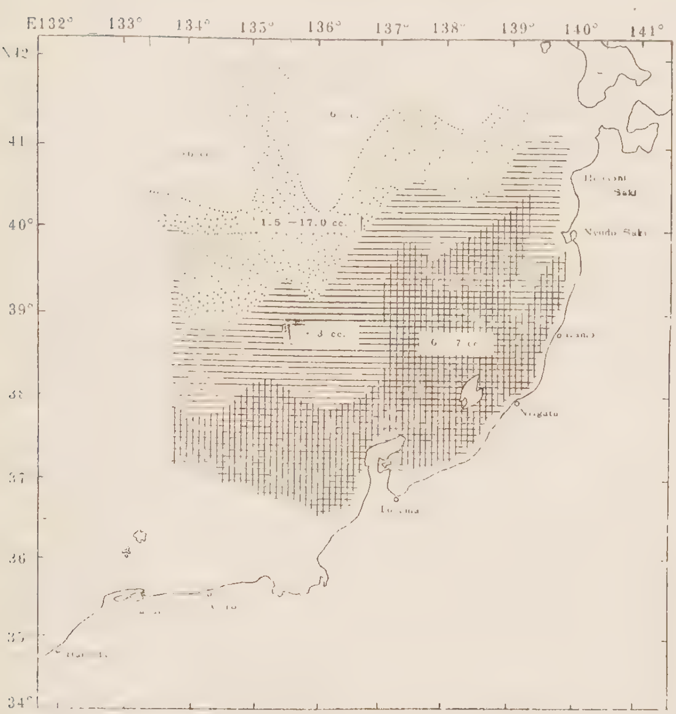


Fig. 6 Geographical distribution of settling volume (cc.) of total plankton organisms.

last autumn (1954), the water temperature of the Japan Sea has generally continued 2-3°C. higher than in normal year and also the horizontal extent of the warmer region grown progressively wider. Therefore, in the present observations, the warmth-loving forms of phyto-plankton as well as zoo-plankton were sampled at every station. Especially, the warmth-loving forms like following species were sampled always at each station alike in the neritic regions and the offing (the Liman Current regions) ;

Table 3 Relation between water masses and settling volumes.

Water masses		Settling volume for 24 hours (cc.)	Characteristics of Settling volume
The Tsushima Current	The 1st Branch	6 ~ 7	Settl. vol. is the largest and the graphical variations are the least.
	The 2nd Branch	< 3	Sett. vol. is the smallest.
	The 3rd Branch	1.5~17	Geogr. variations are the largest.
Liman Current regions		> 6	Both sett. vol. and geographical variations are considerably large.

it demonstrates the mighty flowing of the Tsushima Current in this summer.

Limacina helicina
Calanus helgolandicus
Oithona plumifera
Parathemisto oblivia
Pyrocystis pseudonoctiluca
gen. *Caratium*
Rhizosolenia styliformis

Of course the settling volume is not always in proportion to the number of number of total species including zooplankton and phytoplankton, since plankton samples captured at any station are composed of creatures of various sizes and

forms. Yet, viewed from its constituents, the geographical distribution of the settling volume indicates well the characteristics of each water mass as follows :—

(1) The 1st Branch is the inshore current of the Tsushima Current and much subject to the influence of the neritic waters. Reflecting this sea conditions, the plankton in this region is not only abundant in the number of species of warmth-loving forms but also of neritic forms, such as larval forms, as previously mentioned ; and then both zooplankton and phytoplankton abound in the number of species and in the number of organisms or cells for each species.

The remarkable "dominant species" in this region are the follwing 9 species.

Creseis acicula
Oncaea venusta
Penilia Schmackeri
Pyrocystis pseudonoctiluca
gen. *Ceratium*
Rhizosolenia styliformis
Chaetoceros coarctatus
Thalassiothrix longissima
Acanthometron pellucidum

(2) But in the 2nd Branch, the main flow of the Tsushima Current, phytoplankton is, numerically, more abundant than zooplankton and is volumetrically just reverse to the abovementioned. In this region, both in zooplankton and phytoplankton, the high abundance of the number of species and cells does not occur, differing from the 1st Branch. The leading components in this region are the following 3 plant species.

Phyrocystis pseudonoctiluca
gen. *Ceratium*
Rhizosolenia styliformis

As for zooplankton, there is no any appreciable dominant species exclusive of *Acanthometron*, *Creseis acicula* and the like, flourishing only locally.

(3) In the 3rd Branch - the mixing region with the Liman Current region - the number of total species decreases still more. The remarkable features in this region is the fact that phytoplankton appears scarecely, and that zooplankton also decreases in number generally, though the geographical variation is considerably large. To sum up, this region indicates the intermediate characteristics between the 2nd Current and the Liman Current regions mentioned in the next clause (4) and forms the mixing area of the warmth-loving forms with the low-temperature species.

(4) In the Liman Current regions, the plankton constituents change into the larger forms such as *Calanus cristatus*, and phytoplankton disappears entirely. The dominant species in this region are the following low-temperature species.

Calanus cristatus

Oithona plumifera
Oithona nana
Aglantha digitale
Eucalanus giesbrechti
Metridia lucens
Parathemisto oblivla
Larger Sagitta

Thence, in this region the number of total organisms is least compared with the other three regions, relatively increasing in settling volume.

4. Acknowledgement

The author was aided by Dr. Y. Matsue, professor of Tokyo University and his assistants in collecting the material at the sea. He was aided also by Capt. K. Imamura of the research vessel "Sôyô Maru" and the crew in the laborous and time-consuming work on board. To all these gentlemen the author wishes to express his hearty thanks.

5. Summary

(1). The material for this study was collected during the period Aug. 13 30, 1955, at 35 stations in total. At each station a vertical haul was made through the uppermost 50 metre layer. The qualitative composition and settling volume were studied upon these samples. And the geographical distribution of these planktological properties are discussed in relation to physical conditions of the sea.

(2). The number of total species, including zooplankton and phyto-plankton to occur at one station fluctuates between 7 and 43. The settling volume of total species varies between 0.7 cc. (St. 1) and 18.0 cc. (St. 19).

(3). The close relations between the number of total species & the settling volume of total plankton organisms (i. e. zooplankton and phytoplankton not segregated) and the each of the three branches of the Tsushima Current & the offshore low-temperature regions (the Liman Current regions) are discussed, resulting in the same relations as the author's previous reports (1954).

(4). Picking up the dominant species, the distinguishing features on the plankton components in each of the four water masses mentioned above are shown.

(5). To sum up, in the Japan Sea in August, the warmth-loving species are found throughout the whole area so far as the neritic region of the continent (Siberia) and shown the mighty flow of the warm Tsushima Current, since the last autumn.

6. Literature

1. Gran, H. H. (1905). Diatomeen. *Nordisches Plankton. XIX, Botanischer Teil.* In

German

2. Hustedt, F. (1930). Die Kiesel algen Deutschlands, Östereich und der Schweiz mit Berüksichtigung der übrigen Länder Europas sowie der angrenzende Meeresgebiete. I-II Teil. (Rabenhorst's Kryptogamen-Flora von Deutschland, Östereich und der Schweiz. Bd. VII). In German.
3. Mori, T. (1937). The pelagic Copepoda from the neighbouring waters of Japan. Tokyo. Yokendo. In English.
4. Shimomura, T. (1954). Planktological study on the warm Tsushima Current regions-I & II. *Ann. Rep. Japan Sea Reg. Fish. Res. Lab.*, 1. In English.
5. Kokubo, S. (1955). Plankton Diatoms. Tokyo. Nihon Gakujutsu Shinkokai. In Japanese.

Appended Table 1 Plankton captured with "maru-toku" net during the period August 13-30, 1955

● ○ : Dominant species

St. No.	1	2	3	4	5	8	9	10	11	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	31	32	33	34	35	36	37	38	40
Latitude (N)	40°34.4'	40 35	40 36.2	40 35	40 35	39 25.5	39 18.5	39 08	39 08	39 05.8	39 02.8	39 25	39 50	40 13.5	40 35	40 34	40 32	39 58	39 47	[illegible]	[illegible] 08	[illegible] 48	[illegible]	[illegible]	[illegible]	38 03	38 24.5	38 48	37 12.5	37 31	37 [illegible].5	40 15.0	40 [illegible]	40 [illegible]	41 [illegible]
Longitude (E)	139° 38.7'	139 15.5	138 51.2	138 26	138 01	138 39.6	138 53.7	139-12	139 31	139 41.3	138 10	137 55	137-37	137 19	137 04	136 04	135 15	135 20	136 03	136-35	136-18	136-39	137-05	137-34	137-08.5	136 41.5	136-11	135-42	135-17	134-50	134 23	133-52.5	[illegible]	[illegible]	[illegible]
Date	VIII. 13	〃	〃	〃	VIII. 14	VIII. 15	〃	VIII. 16	〃	〃	VIII. 19	VIII. 20	〃	〃	〃	VIII. 21	〃	〃	〃	VIII. 22	〃	〃	〃	VIII. 23	VIII. 26	VIII. 27	〃	〃	VIII. 28	〃	〃	〃	〃	VIII. [illegible]	VIII. [illegible]
Time	10h. 30m	14-20	17-40	23 35	03 45	20 30	23 50	03 05	05 25	07-15	20 20	01 50	07 25	12 20	16 20	03 45	12 11	16 38	21-40	02-45	06-57	11-55	21-16	04-15	21-50	02-30	17-00	23-15	04 40	08-20	[illegible]	[illegible]	[illegible] 40	[illegible]	14 [illegible]
Inclination of wire of net (°)	15	12	34	10	15	15	10	6	10	11	35	45	21	0	26	20	13	13	18	12	21	11	4	16	3	[illegible]	9	[illegible]	[illegible]	15	18	16	17	[illegible]	[illegible]
Settling volume for 24 hours (cc.)	0.7	1.1	2.1	4.5	5.0	7.5	5.7	1.6	6.0	4.0	6.3	6.1	2.7	3.5	1.6	18.0	17.0	1.5	5.0	5.2	1.9	2.4	2.8	6.4	6.3	5.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.0	5.5	8.6	[illegible]
Zooplankton																																			
Rhabdonella sp.																																			
Salpingella sp.																																			
Epiplocylis sp.																	○	○																	
Diphyes appendiculata Eschs.																	○	○																	
Muggiae atlantica Cuun																																			
Aglantha digitale Haeckel													○												○	○									
small *Medusae*						○	○										○																		
Planktomya Henseni Simroth						●													○	○															
Limacina helicina (Phipps)		○	○	○		○		○			○	○		○			○	○	◎	◎	○		○												
Creseis acicula Rang.	○	○	○			○	○	○	○	○	○	○	○	○	○							●	◎		○	○									
Calanus helgolandicus (Claus)							○					○																							
〃 *plumchrus* Marukawa			◎	○		●		○	○		○	○	○	○				●	◎	○	◎	○	○	○	○	○				○					
〃 *minor* (Claus)			◎		●					○		○			○	●	○	●			○													●	●
〃 *cristatus* Kröyer										○		○																							
〃 *tenuicornis* Dana			◎													○	○	○	○							○									
〃 *darwini* Lubbock																																			
Acrocalanus sp.																																			
Eucalanus giesbrechti sp. nov.	○																																		
〃 *crassus* Giesbrecht										○	○	○	○	○			○	◎	○	○			○				○								
Euchaeta sp.											○																								
Scolecithricella minor (Brady)			○	○	○																														
Scolecithrix dana (Lubbock)																		○	○	○															
Lucicutia flavicornis Wolfenden											○																								
Temora discaudata Giesbrecht							○																												
〃 *stylifera* (Dana)						○	○	○	○	○	○	○	○	○																					
Labidocera japonica Mori				○	○																														
〃 *detruncata* (Dana)																○	○				◎		○												
Metridia lucens Boeck				○	●																														
Mecynocera clausi Thompson							○					○							○	○			○												
Candacia pectinata Brady																			○	○			○												
Acartia danae Giesbrecht						○		○				○	○										○												
Centropages bradyi Wheeler	○					○		○		○	○	○	○	○	○	○							○												
Oithona plumifera Baird		○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	◎	○	○	○	○	○	◎	○	○	○		○	○				○
〃 *similis* Claus	○					○																													
〃 *nana* Giesbrecht			○			○					○																								
Setella gracilis Dana									○								○	○	○	○	○		○				○				○				○
Microsetella norvegica (Boeck)													○																						
Clytemnestra scutellata Dana												○																							
Oncaea venusta Philippi						○				○	○						○																		
〃 *media* Giesbrecht	○	○				○	●	○	◎	○	○	○	○	○						○	○	◎	○	○	○	○	●	◎		○					
Corycaeus lautus Dana						○	○		○												○														
〃 *speciosus* Dana	○	○	○		○	○		○				○	○	○	○				○				○												
Copilia mirabilis Dana										○											○	◎		○	○	○	○	○							
〃 *longistylis* Mori									○	○	○	○	○									○				○									
Penilia Schmackeri Richard	●	○	○			○	○	○	◎	○	○	○	○	○									○												
Evadne tergestina Claus	○	○		○									○	○							○	○	◎	○	○	○									
Podon polyphemoides Leuck								○												○	○		○	○	◎	○	○	○	○	○					
〃 *Leuckarti* G. O. Sars																							○		◎	○									
Parathemisto oblivia Kroeyer	○		○	○	○	○		○			○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○			
Phrosima semilunata Risso ?																				○			○												
Oxycephalus porcellus Claus											○																								
Lucifer raynaudii Bate		○					○				○	○	○	○	○					○	○	○		○	○	○									
Cypridina hilgendorfii G. W. Müller				○										○								○	○	○	○	○									
Sagitta bedoti Béraneck															○	◎							○				○								
〃 *elegans* Verril	○					○																													
〃 *ai* Tokioka																		○																	
〃 spp.		○		○	○		○	○	○	○	○	○	○				○		○		○	●	○		○	○			○					○	○
Doliolum nationalis Bergert	○					◎	○	○	○	○	○	○	○	○				○			○	○	○	○	○	○	○								
Oikopleura fusiformis Fol.																																			
〃 spp.	○	○					○	○	○	○			○	○			○				○	○													
Fritillaria pellucida Busch															○																				
〃 *haplostoma* Fol.		○																																	
〃 spp.																																			
Zoea larva (*Brachyura*)										○		○		○									○	○	○	○									
Megalopa larva (*Brachyura*)																																			
Engraulis japonica Temminck et Schlegel (*larva*)							○				○	○								○															
〃 〃 (*egg*)	○	○				○			○					○								○													
Alima larva												○																							
Maurolicus Pennanti Walb (*egg*)																							○	○											
Zoarcidae or *Brotulidae*												○																							
Ophiopluteus larva	○		○					○														○	○		○	○									
Polychaeta larva											○	○											○												
Auricularia larva																							○												
Decapoda (*Cephalopoda*)																																			
Nauplius larva																	◎																		
Euphausia larva				○	○			○			○		○			○			○	○															
Phyto plankton																																			
Globigerina bulloides d'Orb			○			○	○	○	○		○	○	○	○							○					○	○								
Amphilonche belenoides Hkl.		○																																	
Acanthometron	◎	●				○	○	○		○	○	○	○				●					●				●									
Tripleen		○												○								○													
Trichodesmium contortum Wille		○	○								○	○																							
Pyrocystis pseudonoctiluca Murray	●	○	○	○		●	◎	○	◎	◎	●	○	◎	○	○					○	○	○	○	○	○	○	○	○	○	○	○				
〃 *lunula* (Ehrbg.) Cleve			○						○													○				○									
〃 *fusiformis* Murray										○	○											○					○								
Ceratium inflexum (Gourr) Kofoid	○	○		●			○	○			○									○		○													
〃 *macroceros* (Ehrbg.) Cleve	○	○	○																○	○															○
〃 *tripos* O. F. Müller	○	○																																	
〃 *tripos var. atlanticum* Ostenfeld																	○	○					○									○			
〃 *lunula* Schimper								○		○											○														
〃 *lunula f. brachyceros* Jörg.			○							○	○	○	○	○																					
〃 *lunula f. megaceros* Jörg.	○	○																																	
〃 *Massiliens* (Gourr) Jörg.	○	○								○		○											○		○										
〃 *trichoceros* (Ehrbg.) Kofoid													○			○																			
〃 *vultur* Cleve																																			
〃 *tenue* (Ostf. et Schm.) Jörg.							●	○															○					○							
〃 *sumatranum* (Karsten) Jörg.								○																											
〃 *sumatranum f. angulatum* Jörg.								○																	○										
〃 *candelabrum* (Ehrbg.) Stein	○	○																										○							
〃 *pulcellum* B. Schröder																												○							
〃 *carirense var. volans* (Cleve) Jörg.	○	○																							○										
〃 *carriense f. ceylanicum* (B. Schr.) Jörg.				●		●	●		◎	○	○		●	○				○			○		○		○										
〃 *bucephalum var. heterocamptum* Jörg.																																			
〃 *gracile* Jörg. *var. symmetricum* (Pav.) Jörg.																																			
〃 *fusus* (Ehrenberg)										○							○	○																	
〃 *fusus subsp. seta* (Ehr.) Jörg.	○					○	○	○	○			○	○										○			◎									○
〃 *humile* Jörg.																																			
Rhizosolenia styliformis Brightw.	●	●	○				○	○	○		●		○		○	○				◎	○	○	○	○		○	○	○	●	○	○	●			
〃 *styliformis var. latissima* Brightwell	●	●						○	○	○			○										○			○	○								
〃 *alata f. gracillima* (Cl.) Grunow	○																																		
〃 *acuminata* (Péragallo) Gran								○		○		○		○	○	○				◎		○	○												
〃 *Bergonii* H. Péragallo																										○	○		○						
〃 *setigera* Brightw.																																			
〃 *calcar-avis* Schultze								○																											
Chaetoceros coarctatus Lauder	○	○				○			○	○	●	○	○	○	○	○					○	○	○		○	○	○	○	○						
〃 *curvisetus* Cleve	○																																		
〃 *atlanticus* Cleve								○																											
〃 *concavicornis f. volans*																	○	○																	
〃 *Lorenzianus* Grunow																		○																	
〃 *socialis* Lauder															○																				
Thalassiothrix nitzschiodes Grun.	○	○				○		○		○																									
〃 *longissima* Cl. & Gr.	○	○	○					○	○								○	○		○	○		○			○	○	●	○	○	○				
〃 *Frauenfeldii* (Grun.) Cl. & Gr.										○												○	○		○										
Coscinodiscus gigas Ehrenberg																																			
Climacodium Frauenfeldianum Grun.												○	○	○																					
Stephanopyxis Palmeriana (Ehr.) Grun.																																			

Geographical Distributions of Larval Fishes, Decapoda, Arthropoda and Various Eggs in the Japan Sea (in August, 1955)

by

Toshimasa SHIMOMRUA

Preface

The present studies are based on materials collected during the period August 13 31, 1955 on board the "Sôyô Maru", research vessel of Fisheries Agency of Japan. Position of the stations are given in figure 1. The main purpose of the studies is to get the figure of geographical distribution of the above mentioned larvae and eggs and to get a hint of migrating habits of important marine creatutes in upper layers

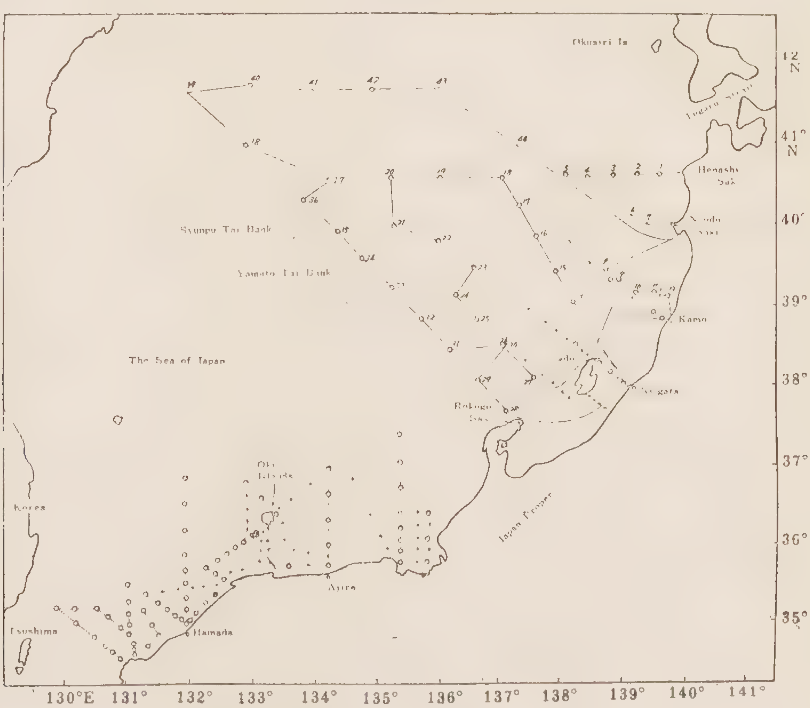


Fig. 1 The positions of the sampling stations.

Solid lines indicate the course of the" Sôyô Maru" and broken lines that of vessels of each Prefectural Fisheries Experimental Station.

Arabic numerals on the solid lines denote the station number.

Mark • indicates the station at which ordinary oceanographical observations were made without towing of "maru-chi" net.

of those regions where are certainly bounded by particularities of the water systems, especially of the warm Tsushima Current and the cold Liman Current.

Materials were collected by horizontal towings of "maru-chi" net for 10 minutes at the speed of about 2 kts.. The horizontal towings were made at the sea surface. The "maru-chi" net is made as shown in figure 2.

The contents treated in this paper are only the first step to the bright prospects. Hereafter, the materials should be piled up more and more.

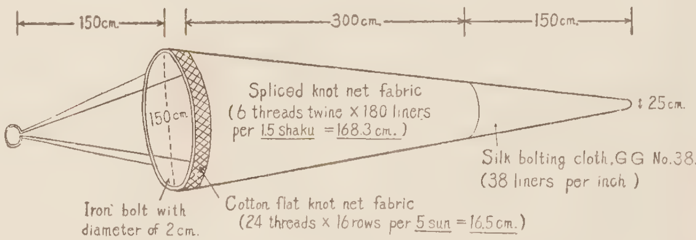


Fig. 2 Constructoion of "maru-chi" net for larval fishes.

The author was aided by Dr. Y. Matsue, professor of Tokyo University and his assistants, Mr. Y. Komaki and Mr. M. Murano in collecting the material at the sea. He was aided also by Capt. K. Imamura and the crew of the "Sôyô Maru" in the laborous and time-consuming work on board. To all these gentlemen the author wishes to express his hearty thanks. Miss Keiko Sakurai has rendered invaluable assistance in microscopy of the materials.

Number of species

"Maru chi" net is able to take not only zooplankton but also a large quantity of microoscpic phytoplankton, notwithstanding the net's meshes larger than "maru-toku" net's and ordinary plankton net's meshes. But in this paper, larvae and eggs of fishes, squids and Arthropoda only should be treated, except so-called true "plankton". A complete list of these species at each station is given in the Appended Table, comprising 23 species of larvae and 3 species of eggs as shown in the next table.

Classificatory groups		Number of species
Laruae	Pisces	14
	Decapoda	1
	Arthropoda	8
Eggs		3

As there are a few species impossible to be identified, the real number of species at the sea would be somewhat much more than in the above mentioned table.

The materials taken by the twelve prefectural fisheries experimental stations from Aomori Pref. to Yamaguchi Pref. along the west coast of Honshu (the mainland of Japan), with "maru-chi" net of the same type as mentioned above and the same horizontal towings, show that, (1) seasonally, the number of species or genera are much (over 30) in the warm season from May to September, more than in the cold season from October to April, when it reducing to about half as much, and that, (2) on the other hand, geographically, the number of species are more abundant in the southern part of the Tsushima Current than in the northern part ; for example,

table 1 gives the species of larvae in the northern part of the Tsushima Current

Table 1. List of species in the northern, central and southern part of the Tsushima Current along the west coast of Honshu, in August 1955.

Prefecture	Date	Number of species	Names of species: Japanese name	Names of species: Technical terms	Total length of body (mm.)
(1) Yamagata	Aug. 18, 1955	3	Katakuchi-iwashi	*Engraulis japonicus* Temminck et Schlegel	7 ～20
			Ishi-dai	*Oplegnathus fasciatus* (Temminck et Schlegel)	8
			Aimme-hagi	*Rudarius ercodes* Jordan et Fowler	6 ～ 7
(2) Wakasa Bay (Fukui Pref. & Kyôto Fu.)	Aug.24～25, 1955	7	Katakuchi-iwashi	*Engraulis japonicus* Temminck et Schlegel	7 ～16
			Kusa-fugu	*Spheroides niphobles* Jordan et Snyder	8
			Himeji-rui	Mullidae	5 ～37
			Amime-hagi	*Rudarius ercodes* Jordan et Fowler	6 ～ 7
			Kawa-hagi	*Stephanolepis cirrhifer* (Temminck et Schlegel)	11
			Sayori	*Hemiramphus sajori* (Temminck et Schlegel)	37
			Miscs.		
(3) Yamaguchi	Aug.23～25, 1955	17	Katakuchi-iwashi	*Engraulis japonicus* Temminck et Schlegel	8 ～23.5
			Eso-rui	*Synodontidae*	14
			Musoku-rui	Apodes	21
			Yôji-uo	*Syngnathus schlegeli* Kaup	82
			Tobi-uo	Flying fish	38.5
			Kamasu-rui	Sphyraenidae	6 ～10.5
			Kanpachi	*Seriola purpurascens* Temminck et Schlegel	19
			Himeji-rui	Mullidae	5 ～13
			Himeji	*Pseudopeneus bensasi* Temminck et Schlegel	8 ～32.5
			Bera-rui	Labridae	9.5～10.5
			Kawa-hagi-rui	Monacanthidae	6 ～19
			Kawa-hagi	*Stephanolepis cirrhifer* (Temminck et Schlegel)	6 ～27.5
			Ma-fugu	gen. *Fugu*	9
			Mino-kasago	*Pterois lunulata* Temminck et Schlegel	7
			Mishima-okoze	*Uranoscopus japonicus* Houttuyn	9.5
			Niji-ginpo	*Dasson trossulus* (Jordan et Snyder)	5 ～23
			Miscs.		

(1) : after H. Fukataki's identification (Japan Sea Reg. Fish. Res. Lab.).
(2) : after H. Fukataki's and Y. Kato's identification (Kyoto Pref. Fish. Exp. St.).
(3) : after T. Ito's identification (Yamaguchi Pref. Fish. Exp. St.).

(Yamagata Pref. as the model), in the central part (Wakasa Bay as the model) and in the southern part (Yamaguchi Pref. as the model). Throughout the year from January to December, the number of species diminish steeply in the region east of Oki Islands, Shimane Pref.. Such an abundance of the number of larvae-species in the region west of Oki Island is entirely the same as the features that, in the southern part of the Japan Sea, there found much species of marine creatures landed more than in the northern part and that also the fish catch is far larger in the southern part than in the northern part (Shimomura, 1957). The samplings by any pref. fish. exp. st. with "maru-chi" net has been conducted over in the area less than 100 nautical miles off Honshu, being operated also the Japan Sea fisheries in the same inshore regions today.

Beyond the Tsushima Current, or in the northern area across the Liman Front (polar front), the geographical distributions of fish larvae and eggs or so were only reported by Suehiro (1942). His research, being conducted over in the Japan Sea during the period late in May-early in June 1941, is differ seasonally from the present research. He could not take, entirely, any material in the cold Liman Current region ; his 15 species of larvae —the total of materials— were taken all within the Tsushima Current regions, i. e. confined to the near side of the polar front. His net measured 150 cm. in the mouth diameter and its meshes 2 mm..

The number of species of varied larvae at each station are given in figure 3. In figure 3 there are shown not only the present research but the ones made by each pref. fish. exp. st. in August of the same year, 1955. As shown in figure 3, the number of species at each station is rather much in the Noto Peninsula — Sado Island region and in the area from st. 14 to 16, in st. 10 to 11, and at st. 1, where are all located in the second Branch of the Tsushima Current, although, viewed geographically, the number of larvae species increases steeply in the region west of Oki Islands, as already reffered to.

Since, in the observating courses conducted over by each pref. fish. exp. st. west of Noto Peninsula, even the far most observation stations do not go out across the Tsushima Current, the geographical characteristics of the distribution of the number of species are not marked so clearly with water masses. Now it would be discussed only on the materials taken by the authors on board the "Sôyô Maru".

Relation between geographical distribution of the number of species and oceanographical conditions

(A) As the horizontal tows with "maru-chi" net were made always at the sea surface, it might be expected that the geographical distribution of the number of larvae species is closely connected with the geographical distribution of isotherms at O-metre layer. But that is not the case. Isotherms at 10-metre layer, also, have not immediate relationship to it, except the fact that the number of species decreases

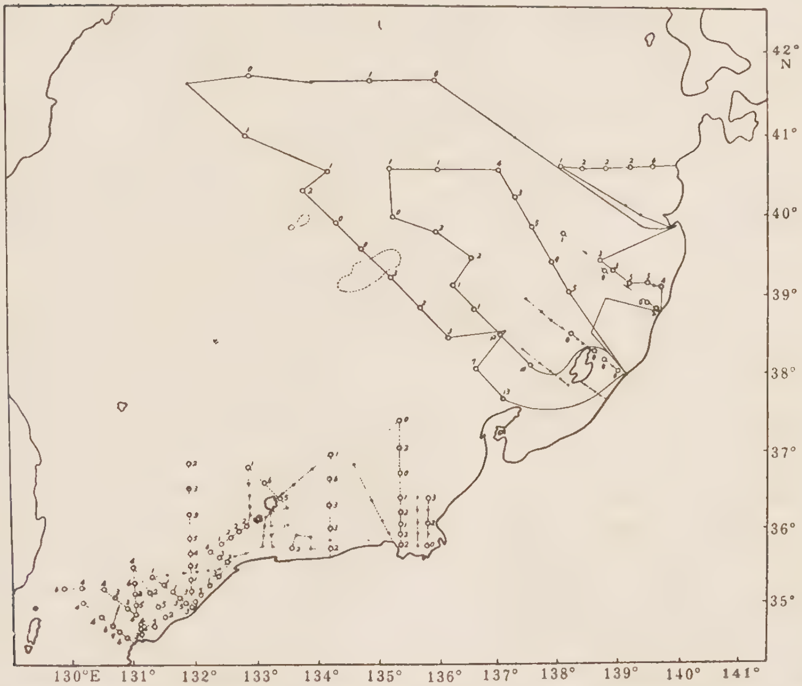


Fig. 3 The number of species of various larvae, at each station, captured during the period August 13-31, 1955.

Solid lines indicate the course of the "Soyo Maru", and broken lines that of vessels of each Prefectural Fisheries Experimental Station.

Mark • indicates the station that the ordinary oceanographical observations were made without the towings of "maru-chi" net.

with latitudes. Isotherms at 25-metre layer show considerably close relationship with it. Then, isotherms at 50 metre layer are first closely connected with it. The considerably close relation are seen also at 75 and 100-metre layer, being not so good as isotherms at 50-metre layer. Down beyond 150-metre depths the relation to the geographical distribution of isotherms becomes decreased with depths.

50-metre layer is so called the intermediate water of the Tsushima Current and situated directly under the Ist (or uppermost) discontinuity, which is located about at 25-metre depths in the Tsushima Current in summer.

From a common-sense point of view, mention should be made to the fact that larvae, drifting or swimming in the upper-most layer, have not immediate relationship to the geographical distribution of the surface temperature but to that of the intermediate water (usually 50-metre depths) of the Tsushima Current. Of course, this does not mean that there is no any relation between the surface temperature and the occurrence of various larvae, but that, in the summer, as the horizontal temperature gradient of the surface layer becomes so gentle, owing to the severe sun rays, southerly winds or so, and yet as the temperature lies within the range in which larvae can exist, the geographical distribution of surface isotherms within

the Tsushima Current is not so closely related to that of the number of larvae species. In this meaning, as previously mentioned, the geographical distribution of the surface isotherms above the first discontinuity separates clearly, from a species-number point of view, the low water temperature regions north of the Liman Front from the high water temperature regions south of it ; in the former the number of larvae species appeared at each station is in general 0 to 1 and in the latter it is 3 to 13.

In the warm Current regions, as previousiy mentioned, the number of larvae species have the closest connection with the geographical distribution of isothems at 50-metre layer, the "intermediate water" of the Tsushima Current. Table 2 shows

Table 2. Relation between the geographical distribution of the number of larvae species and water masses.

Water masses		Number of species	Water temperature at 50 m. layer
The Tsushima Current	The 1st Branch	1～ 6 (usually 3～5)	> 20 °C
	The 2nd Branch	5～13	15～20 〃
	The 3rd Branch	3～ 5	10～15 〃
Liman Current region (including polar front)		0～ 1	< 5 〃

this relation. Of course, the temperature ranges described in table 2 give only an outline for each water mass, especially so is in the vicinity of the Liman Front where varied water masses are complicatedly mingling one another. This is the same as the case of plankton.

(B) Then it is also notewarthy pattern that, in the Liman Current region north of the polar front, the number of larvae species seen at one station is only single one at the most ; but all the stations where larvae occurred, even if it is only a single species, are the very stations subject to the influence of the Tsushima Current —in other words, in the true cold water regions on which the Tsushima Current has no effect, there found no larvae at any station.

Thus it is a characteristic of the Japan Sea that, in the summer, the occurrence of larvae is confined to the Tsushima Current regions ; this is the same as the results obtained during the period the latter part of May-the first part of June, 1941, (Suehiro, 1942) which, seasonally, was conducted over three months ahead compared with the present research.

Why so ? In the Liman Current regions along Enkaishu (ПРИМОРСКИН, U. S. S. R.), June or so are the fishing season of mackerel, then alaska pollacks, flat fishes and sardines were caught in abundance before the Second World War. It seems surely to be so even today from various news. Too, in th coastal region along the east coast of northern Korea, a considerably large quantities of larvae of anchovy, *Engraulis japonicus* Temm. et Schl., were taken in the warm season, before

the Second World War. Such facts show that the spawning season of varied fishes of the coastal regions from northern Korea to Enkaishu (ПРИМОРСКИИ U. S. S. R) lies in the warm season of the year like in that of Japan Proper (or Honshu). The present observation course reached about 50 nautical miles off Enkaishu. Therefore, does the fact that no larva and egg appeared in the present and in the former research during the period May-June, 1941, mean a something of characteristics on the ecology of marine creatures in the Liman Current regions or on the running, eddy and turbulence or the like of the Liman Current ?

As stated in a separate paragraph about oceanographical conditions, the sea conditions of the Liman Current regions north of the Liman Front are more complicated than that of the adjacent waters to Japan Proper, because many branches of the Tsushima Current, including small ones as well as large ones, penetrate into the Liman Current regions— namely, in the Liman Current regions there might be many eddies composed of terrestrial, icy coastal waters, the very waters of the Liman Current and of the Tsushima Current and the like, holding each peculiar property. It would be proper that the existence of such regions mosaicked by varied water masses, frankly speaking of steep temperature gradient, is normal in the waters adjacent to the Siberia continent frozen over in winter, as such patterns in the Antarctic Sea (Shimomura, 1950). Then larvae and eggs are supposed to appear only in considerably small, solitary water masses like each of von Kármán's vortex street, and yet, since these eddies would occur close inshore Enkaishu, in the northern part beyond the present observating courses, it might be guessed at that larvae and eggs were not taken, like during May and June, 1941.

(C) Lastly, the fact that the geographical distribution of larvae and eggs is more closely linked with that of isotherms at the intermediate water of the Tsushima Current than with the surface isotherms, might offer that larvae and eggs have their main habitats in the intermediate water of the Tsushima Current, though these specimens were taken by horizontal towings at the sea surface. Considering the fact that the intermediate water of the Tsushima Current underlies directly the first discontinuity, larvae would have an ability of movements to and from the surface for a good vertical distance, at least, even in the midsummer, surmounting a considerable, vertical temperature gradient ; for example it has long been known that the vertical migration of *Calanus*, as of many other planktonic forms, is considerably great, down to 200-metre depths or so.

Number of organisms and sea conditions

Number of larvae organisms :

Nearly no larvae, as previously mentioned, occur in the coastal region, the Ist Branch of the Tsushima Current, scores of nautical miles off Honshu, even though

including the materials taken by Niigata and Yamagata Pref. Fish. Exp. St.. In farther north regions, as in the geographical distribution of the number of species, the number of larvae organisms diminishes abruptly north of the Liman Front or the 3 rd Branch of the Tsushima Current; the occurrence of larvae is exclusively confined to the Tsushima Current or to the regions subject to it. And yet even within the Tsushima Current, the main occurring region of larvae is the 2nd Branch, so called the main flow of the Tsushima Current —the water temperature range at 50-meter layer is on the whole 15°-20°C. (table 2). But the most widely distributed of all is anchovy larva (appended table and table 1).

(1) **Anchovy larva** (fig. 4).

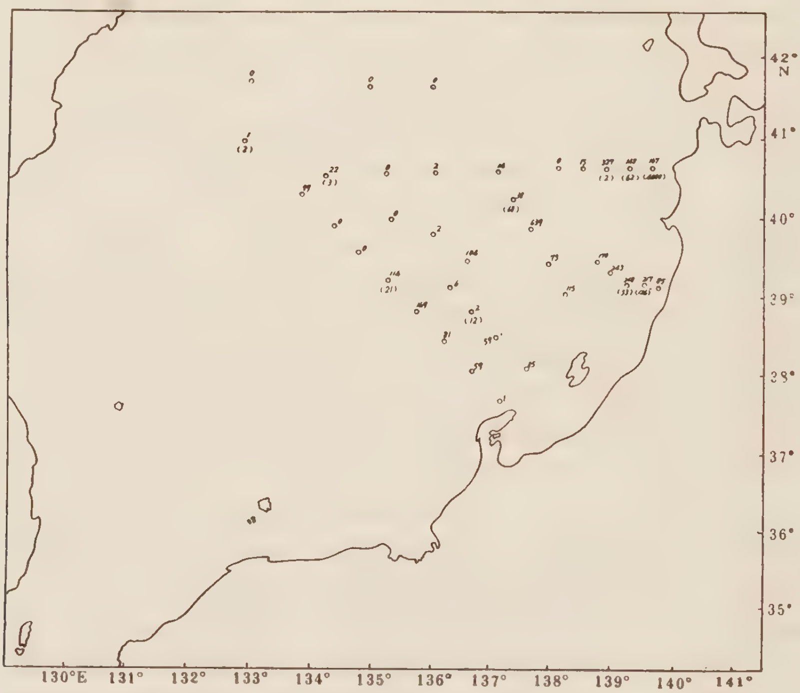


Fig. 4 Geographical distribution of anchovy-larvae individuals and it eggs ( ).

O : station at which towing was made.

As for the monthly change in the occurrence of anchovy larvae, it is touched on collectively in anoter thesis "On the year round occurrence and ecology of eggs and larvae of the principal fishes in the Japan Sea region-1, Chapter 1 Anchovy" ; so that, here it is omitted.

a) From a water-mass standpoint, the main occurring region of larvae is the 2 nd Branch of the Tsushima Current, at least, stations more than one hundred organisms are restricted to the region where water temperature at 50-metre layer is higher than 10°C.. Then, from a surface-temperature point of view, larvae appear only in the waters higher than 25°C. ; in other words the appearance confined to the

waters south of latitude 40° N..

b) The maximum of anchovy larvae organisms is 639 at st. 16. Over Yamato-Tai Bank, for instance at sts. 34 and 35, where is directly connected with "B" water-mass mentioned in a seperate paragraph about oceanographical conditions of the Japan Sea, no larva was taken. Sts. 34 and 35 are located within the low temperature region where the central temperature at 25-metre layer of "B" water-mass above Yamato-Tai Bank shows 5°C., but st. 16 is situated within the region where in the longitudinal section along the NW course off Niigata (sts 14-18), the 2nd Branch is thickened over others.

c) Even in the same water-mass (Branch) of the Tsushima Current, the larvae organisms appear more abundantly on the low temperature side than on the high side. This is similar to the way that, off Sanriku district, the skippjack and saury fishing grounds are found side by side, on the different sides of the 20°C. isotherm.

d) There found interesting geographical peculiarities also in the geographical distribution of larva's body length. From north to south along the west coast of Honshu, in the Tsushima Current, the waters north of the NW course off Niigata are composed mainly of the body length below 10 mm., but it averages 8 mm. in the waters south, with smaller number of organisms seen at one station. In the southern parts of the Tsushima Current, no larva reaches 20 mm. length with the maximum of 17mm., though in the northern warm regions it is larger, being seen even organisms reach 34 mm. at st. 3.

Then, looking at the remoteness from Honshu, larvae in the offing beyond the 3rd Branch of the Tsushima Current is composed chiefly of 7 to 9 mm. body length, showing no any marked geographical peculiarity. Notwithstanding, in such an offing, mention should be made to the fact that sts. 36 and 37 are, being, in striking contrast to anothers in the same offing (the Liman Current regions), almost entirely composed of large-sized anchovy larvae as next table.

St.	Total number of organisms	Range of body-length
36	99	95 : 18～34mm. (mainly 28mm.) 4 : 7～13mm.
37	22	17 : 24～57mm. (mainly 30～33mm.) 5 : 7mm.

It has never been seen before that such large-sized larvae more than 50 mm. in body length were caught in the very "maru-chi" net. In the studies of anchovy for two years from August, 1951 to July, 1953, also, the largest size caught in the Hyuga-Nada Sea and the Bungo Strait between Shikoku and Kyushu is only 32 mm., which is the same as the size fished in the coastal region (Yokota, 1953). And yet, according to the Yokota's report, such larger sizes are occasionally caught, mingling in the small sizes. But at sts. 36 and 37 the majority of anchovy larvae are all such larger sizes. Sts. 36 and 37, as stated previously, are situated in the passage of the branch that flows north-

eastward, branching off west of Yamato-Tai Bank from the 3rd Branch of the Tsushima Current ; it is merely a drift current several metres thick.

(2) **Brachyura larvaea** (fig. 5)

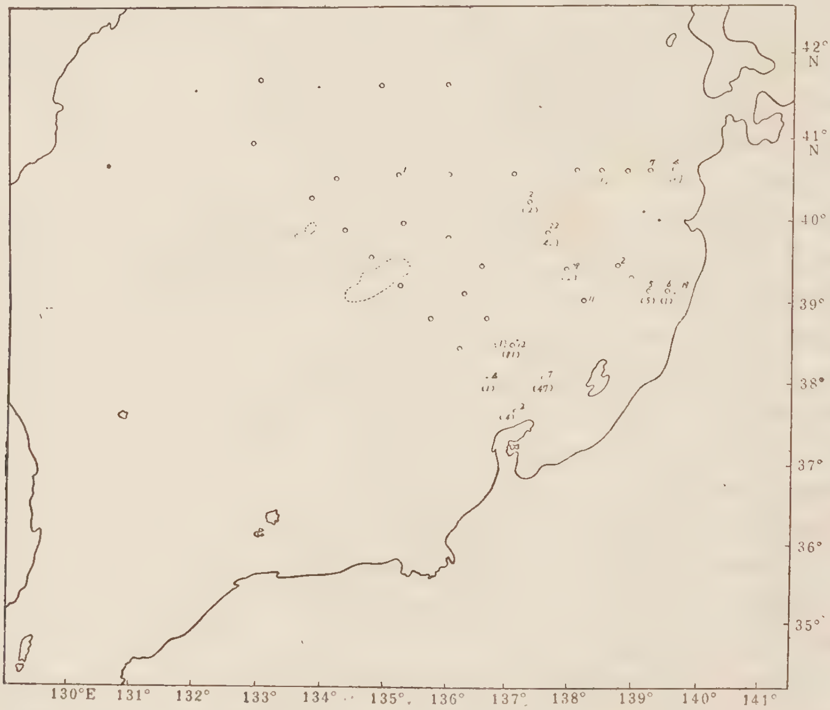


Fig. 5 Geographical distribution of *Brachyura*-larvae organisms — Megalopa larva, Zoea larva ( ), and Porcellana larva ( ).

Brachyura larvae are, with Stomatopoda, the most important group after anchovy larvae. Brachyura caught by fishermen in the Japan Sea is only "zuwai-gani", *Chionecetes phalangium* Fabricius. This species is peculiar to the Japan Sea alone, and the catch, in recent years, has been increasing, reaching about 2,500,000 kan (9,400,000 Kgs.) in 1954. The main fishing grounds are the coastal regions off Ishikawa Pref. to Tottori Pref., and also Niigata Pref.. But whether all the Brachyura larvae taken in this investigation are the larvae of *Chionecetes phalangium* or not is unable to tell, for its development has not been clarified well Figure 7 shows the geographical distribution of Zoea larvae, Porcellana larvae, and Megalopa larvae, all belong to Brachyura and show that the occurring stations are not always confined to within the coastal regions, contray to one's expectations. The most distant appearing station is st. 20, 240 nautical miles off Niigata (in the north-west direction), where there was a single Megalopa larva (twelve thirty on the 21st of August, 1955). Including st. 20, the distribution region of these larvae groups is all located south of the Liman Front, where, in other words, the water temperature at 0-metre layer and 50-metre is, respectively, more than 25°C. and 5°C.. As compared the distribution

region of Zoea larvae with that of Megalopa larvae, developing more than Zoea stage, the latter extends northward more than the former.

Although the adult forms belong to gen. *Porcellana* found around Japan are all neritic and warmer-water species, occurring on the rocky shores, in enbayments and the like, in the present research it was found even at st. 4 forty nautical miles off Henashi Saki, Aomori Pref.. It is impossible to state positively whether this *Porcellana* larva was drifted riding on the current from coastal regions or came upward from the hidden bank in the vicinity.

Adult forms of Zoea larva and Megalopa larva, namely Brachyura creatures, are benthonic, not moving so widely as migrating fishes but only in restricted region on the continental slopes or banks. But the fact that the regions from st. 26 to 27 and st. 15 to 16 located in the northern parts beyond the present trawling grounds operated by fishermen are the regions with the largest number of Zoea larva or Megalopa larva, shows perhaps an existence of somewhat relation to the bottom contours — banks — in the vicinity. It would be expected perhaps that some bank may lie beneath the surface. The current, on an average, runs at the speed of 0.5 knots. The majority of the bottom contours of the Japan Sea, especially in the offing, has been left behind unexplored. Meeting fishermen's urgent requests, new 25 banks have been discovered since 1946, and researched geologically and from a fishing point of view. In the present research, 'Nippon Denki' 103 type sounding machine with availability of sounding the range 0 to 1800 metres and 'Nippon Denki' 10,000-metre sounding machine were operated to take the bottom contours. As the result, a new bank as shown in figure 6 was discovered at st. 26. Dredging on the bank it was clarified that it is composed of volcanic rocks, and that it is covered partially, yet exceedingly thinly, by sand. Small Lamellibranchia attached themselves to the bits of bank's substance and crabs and "kumo-hitode," one of sea-stars, were brought up on the deck. This bank rises upward toward the surface from the sea bed about 1200 metre depth on one side and 650 metre depth on the other, lying about 260 metres under water, and slopes down steeper at its northern edges into much deep water. What and how are the geologic structure of the bank, especially on the slopes which affect the dragnet fisheries profoundly, composed of, must await further searchings into its mysteries. But the dredged specimens evidence the existence of Brachyura as mentioned above, and then cod fish, *Gadus macrocephalus* Tilesius, alaska pollack, *Theragra chalcogramma* (Pallas), flat fish and the like, including Brachyura, have been caught in dragnet by Ishikawa Pref. Fish. Exp. St.. Consequently, it is only right that Brachyura larvae are plentifully found in the vicinity of st. 26, though it is located off beyond the edge of continental shelf.

On the other hand, the fathograms of the bottom contours around st. 16, another flourishing place of Brachyura larvae, were not taken owing to a mishap to machinery. But westward, a little south-east of st. 22, another bank was discovered (fig. 7).

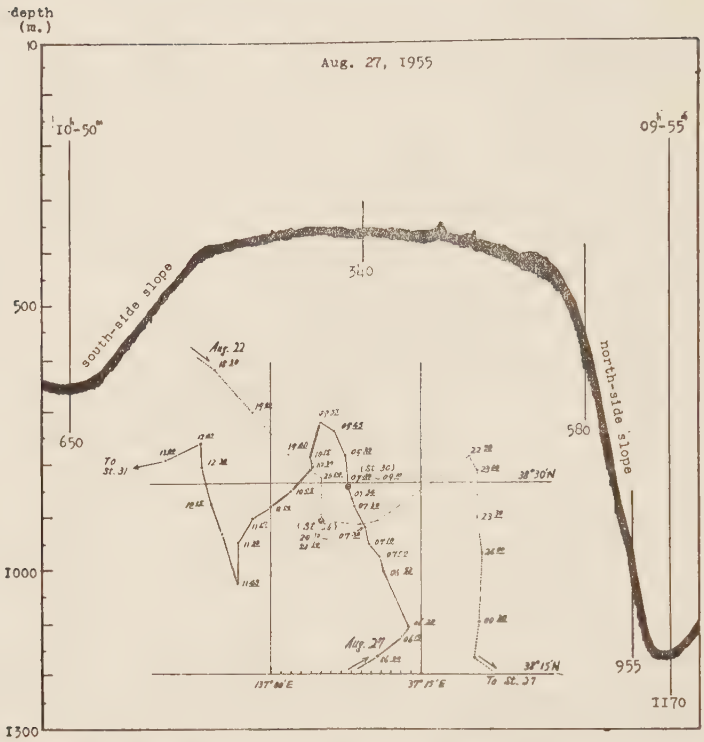


Fig. 6 The hidden bank was discovered by the "Sôyô Maru" in latitude 38°-30′ N, longitude 137°E ; it is 260 metres below the surface.

The thick line denotes the course in which this bottom contour was taken . the Arabic numerals on the courses denote times.

As the moving pen of the fathometer traced the depth contours, it began abruptly to rise an outline of a steep-sided sea mount, standing solitarily on the bed of the sea, about in latitude 39°-40′ N. and longitude 136°-15′ E. This pinnacle-like ledge rises abruptly 1700 metres above the bottom floor, lying about 930 metres under water. On the whole, in the vicinity of Yamato-Tai Bank and Shunpu-Tai Bank, including these two, especially in the eastward, are many small banks ; and the present bank is located eastward beyond the cluster of these small banks. As also seen in figure 7, in the vicinity, fathogram shows peculiar bottom contour, lacerated floor, which has been seen nowhere else in the Japan Sea, giving the impression of some series formed by the interplay of volcanic outpourings and the like. Thinking of such a crust's line, extending it more eastward, it may be suspected that there will be some bank also beneath st. 16. If it were so, it will be convincing that a flourishing area of Zoea larvae is fomed around st. 16. Hereafter, various researches should be made in this area.

A single Megalopa larva taken at st. 20 seems to be drifted riding on the small branch of the Tsushima Current, flowing northward in the region north of Yamato-Tai Bank. If so, it's spawning grounds may be Yamato-Tai Bank or Shunpu-Tai Bank

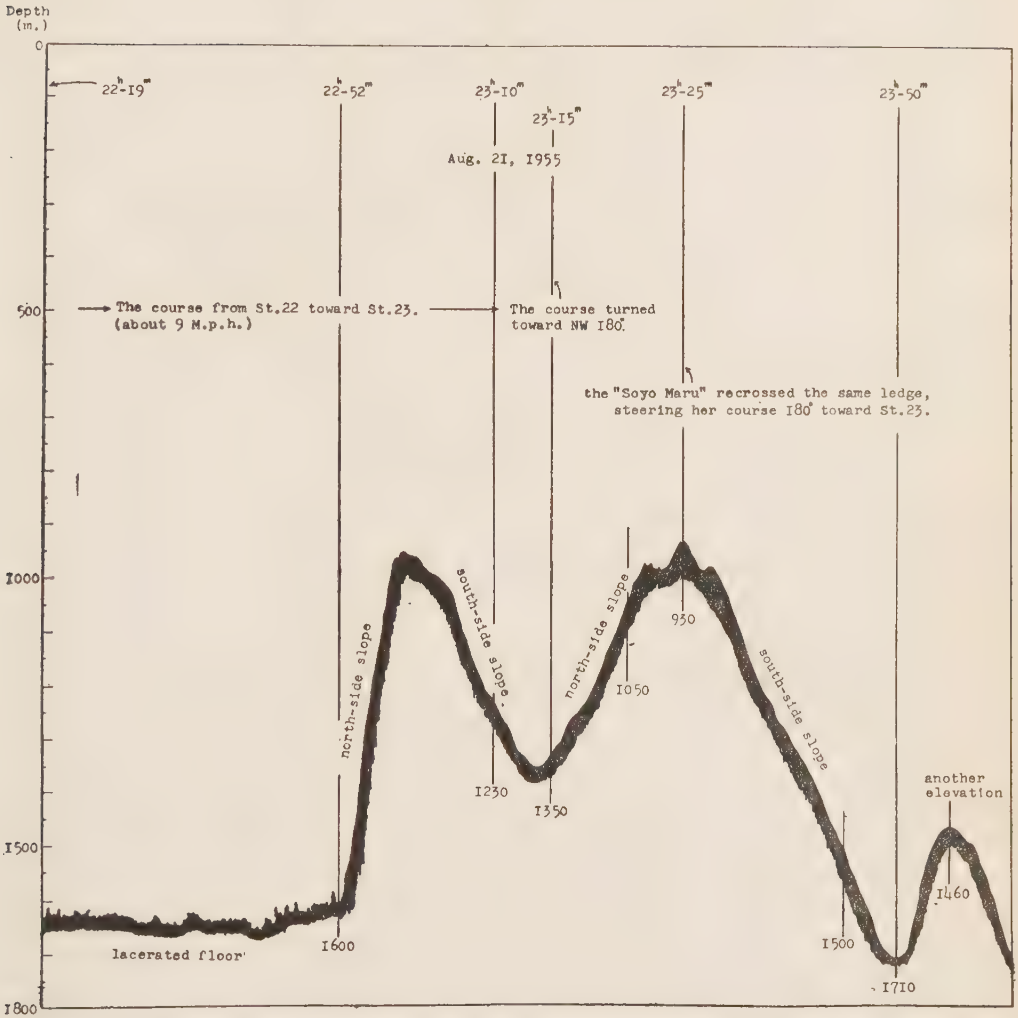


Fig. 7 The hidden ledge discovered by the "Sôyô Maru" in latitude 39°-40′ N, longitude 136°-15′ E ; it lies 930 metres under water.

itself ; especially, the shallowest areas of Yamato-Tai Bank lies only 250 metres under the surface, being good, in a water-depth point of view, to the existence of crabs. But around Yamato-Tai Bank and Shunpu-Tai Bank no Zoea larva, no Megalopa larva, and no Porcellana larva were taken at all. Consequently, where come the Megalopa larva at st. 20 from, is beyond conception.

Stomatopoda larva : (fig. 8)

Larval forms of Stomatopoda taken in the present research are only two forms, Erichthus larva and Alima larva. Their appearings are confined to more coastal regions than that of Brachyura larvae, becoming extinct in the offing beyond the 3rd Branch of the Tsushima Current, including the Liman Front. But within the near side

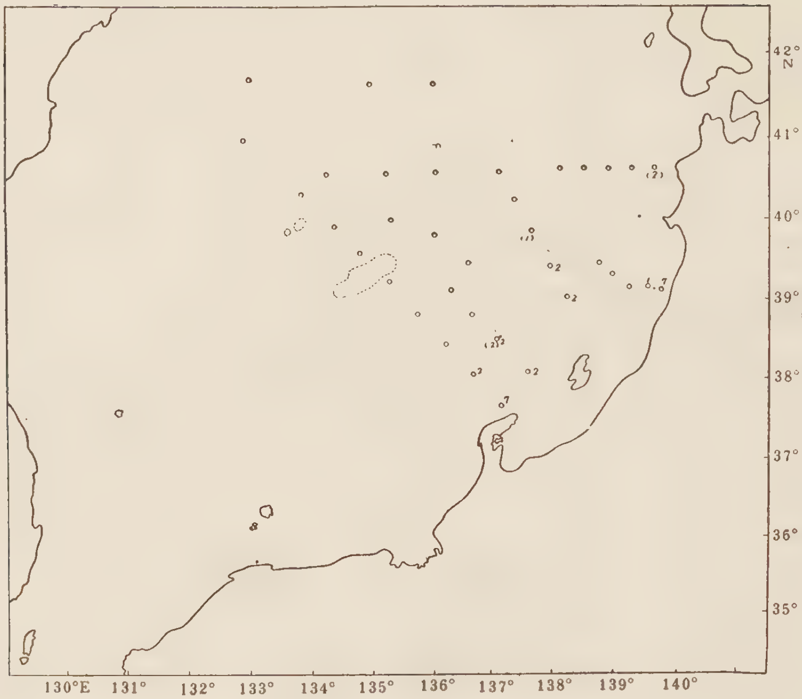


Fig. 8 Geographical distribution of *Alima* larvae and *Erichthus* larva ( ) individuals.

of the Liman Front, in the 2nd and Ist Branches of the Tsushima Current, the geographical distribution of stations at which Stomatopoda larvae were taken shows the same as that of Brachyura larvae. The above-mentioned would be in the nature of facts that their adult forms have the same characteristics as that of Brachyura. Then, reflecting the fact that, in the Japan Sea, there is no fisherman specialized in the squilla fishery, number of larvae taken in the present research is so small as shown in figure 8.

Summary

1) This study is concerned with the geographical distribution of larvae of fishes and other important marine animals and its relation to the sea conditions, the flow of Tsushima Current and the Liman Current beyond it, in the Japan Sea during the period August 13-31, 1955. It is to be a first step to a complete investigation of migrations and their relation to the running features of the warm Tsushima Current and the cold Liman Current.

2) The number of total species or genera of larvae identified are more than 23, comprising 14 of fishes, 1 of squid and 8 of Arthropoda; and then the eggs identified are only 3 species —anchovy, *Engraulis japonicus* Temm. et Schl., mackerel-pike, *Cololabis saira* (Brevoort) and Decapoda (Cephalopoda).

3) The number of total species or genera of larvae varies with geographic-

positions from 0 (at several stations) to 13 (st. 23). On the basis of the geographical distribution of these number, various characteristics are distinguished in the present waters as follows :

i) Along the west coast of Honshu the number of species or genera are greater in the southern parts than in the northern parts.

ii) The appearance of larvae is almost confined to the Tsushima Current region or at least to region subject to the Tsushima Current.

iii) In the Tsushima Current regions, number of larvae species or genera to be found at a single station varies, as a whole, between 3 and 13. It is noteworthy that the number differs in the three regions - the Ist, 2nd and 3rd Branch of the Tsushima Current ; especially, the main flow, the 2nd Branch of the Tsushima Current, is most abundant in the number, while the Ist Branch, the most neritic region, is poorer than in the 2nd.

4) Of larvae, anchovy is the most imporant in respect to the extent of occurring and also in respect to the number of organisms, and then Zoea larva and Megalopa larva belonging to Brachyura, and Erichthus larva and Alima larva belonging to Arthropoda.

With reference to anchovy larva, the geographical distribution of the number of individuals, its relation to water masses, the geographical differences of body length and the like are discussed.

Of other creatures, as to Brachyura larva which lives on the bottom floor, its relation to the bottom contours is discussed, and the presumable existence of an unknown hidden bank around st. 16, never seen before, is suspected.

Literature

1. Shimomura, T (1950). On the sea-condition and whaling of the Antarctic Sea (1946-1947). *Jour. Oceanog. Soc. Japan.* 5 (2-4). In Japanese.
2. Shimomura, T. (1957). A general review of the Japan Sea's fishing conditions in the year 1954. *Bull.Japan Sea Reg. Fish. Res. Lab.* 6. In Japanese.
3. Suehiro, Y. (1942). Report on the fishes in the Sea of Japan on board "Sôyô Maru". *Jour. Imp. Fish. Exper. St.* 12. In Japanese.
4. Yokota, T. (1953). Studies on the sardines in Hyûga-Nada and Bungo-Strait. *Rep. Nankai Reg. Fish. Res. Lab.* 2. In Japanese

Appended Table : The larva species captured in the Japan Sea during the period August 13~31, 1955.

St. No.	1	2	3	4	5	8	9	10	11	13	14	15	16	17	18
Latitude (N)	40 34.4′	40 35	40 3[illegible]	40 35	40 35	39 25.5	39 18.5	39 08	39 08	39-05.8	39 02.8	39 25	39-50	40 13.5	40 35
Longitude (E)	139 38.7′	139 15.5	135 51.[illegible]	138 26	138 01	138 39.6	138 53.7	139 12	139 31	139-41.3	138 10	137 55	137 37	137 19	137 04
Date	VIII. 13	〃	〃	VIII. 14	〃	VIII. 15	VIII. 16	〃	〃	〃	VIII. 19	VIII. 20	〃	〃	〃
Time	12h 10m	15-30	21-00	01-10	06-10	21 30	00 20	03 20	05 30	07 30	21 10	02 50	08 10	12 30	17 40
Settling volume for 24 hours (cc.)	17.0	18.0	35.0	18.0	3.0	65.0	73.5	28.0	27.0	19.0	63.5	64.0	50.5	23.0	19.0
Larval forms															
Engraulis japonicus Temm. et Schl. (*Katakuchi-iwashi*)	167(6~19, A.8)	143(5~14, A.11)	327(6~34, A.11)	15(6~13, A.10)		170(7~22, A.10)	243(8~21, A.10)	348(8~20, A.10)	217(5~16, A.10)	85(7~13, A.10)	115(7~20, A.10)	75(5~29, A.7)	639(5~10, A.8)	38(7~10, A.8)	14(6~8, A.7)
Cololabis saira (Brevoort) (*Sanma*)	…	…	…	…	1	…	…	…	…	…	…	…	…	…	2(6,8)
Scomber japonicus Houttuyn (*Hon-saba*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Pseudopeneus bensasi Temm. et Schl. (*Himeji*)	…	…	…	…	…	…	1(47)	…	…	…	…	…	…	…	…
Fugu vermicularis porphyreus (Temm. et Schl.) (*Ma-fugu*)	…	…	…	…	…	…	…	1(37)	…	…	…	…	…	…	…
Cypselurus opisthopterus hiraii Abe (*Hosotobi*)	…	…	…	…	…	…	…	…	…	…	…	1(91)	…	…	…
Cypselurus heterurus döderleini (Steindachner) (*Tsukushi-tobiuo*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Coryphaena hippurus Linné (*Shiira*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Ablennes Jordan et Fordice (*Datsu*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Synanceiidae (*Okaze*)	…	…	…	…	…	…	…	…	…	…	…	2(2.5, 2.7)	…	…	…
Auxis Cuvier (*Sôda-katsuo*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Chromis Cuvier (*Suzume-dai*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…darius erodes Jordan et Fowler (*Amime-hagi*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…apoda (*Cephalopoda*) (*Ika*)	12(6~11)	…	…	…	…	…	…	…	…	…	…	4	…	…	1(3)
…ers	…	…	6	…	…	1	3(5, 3, 3)	1	1	…	2(4,8)	1(1.7)	1(4)	…	16(3)
…a larva	…	…	…	…	…	…	…	5	1	…	…	2	48	2	…
…ellana larva	1	…	…	1	…	…	…	…	…	…	…	…	…	…	…
…alopa larva	4	7	…	…	…	2	…	5	6	19	11	28	22	2	…
…chyura larva	1	…	…	…	…	…	…	…	…	10	1	…	…	…	…
Mysis stage (*Macrura*) larva	…	…	…	…	…	…	…	…	…	…	…	16	…	…	…
Erichthus larva	2	…	…	…	…	…	…	…	…	…	…	…	1	…	…
Alima larva	…	…	…	…	…	…	…	…	1	7	2	2	…	…	…
Red shrimp	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Eggs															
Engraulis japonicus Temm. et Schl.	4,000	62	2	…	…	…	…	53	126	…	…	…	…	68	…
…olabis saira (Brevoort)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	35(two groups)
…apoda (*Cephalopoda*)	…	3	3	3	…	3	…	1	…	…	…	…	…	7	24
…ers	…	…	…	…	…	…	1	92	…	16	…	46	…	33	31

St. No.	19	20	21	22	23	24	25	26	27	28	29	31	32	33	34	35	36	37	38	40	42	43
Latitude (N)	40 34	40 32	39-58	39-47	39-27	39 08	38 48	38-27	38 04	37 39.5	38 03	38-24.5	38-48	39-12.5	39-34	39-52.5	40 15.6	40 30	40-56	41-42	41-38.5	41-38.5
Longitude (E)	136 04	135-15	135 20	136-03	136-35	136 18	136 39	137-05	137 34	137-08.5	136-41.5	136-11	135-42	135-17	134-50	134-23	133 52.5	134 18	132-55.5	133-00	134-58.5	136 01
Date	VIII. 21	〃	〃	〃	VIII. 22	〃	〃	〃	VIII. 23	VIII. 26	VIII. 27	〃	〃	VIII. 28	〃	〃	〃	〃	VIII. 29	VIII. 30	VIII. 31	〃
Time	04 30	12 30	16-50	21-50	03-20	07-50	13 50	21-30	04 20	22 10	03-20	18-40	23-40	04-50	09 00	14 00	19 30	23 50	09-30	14-10	07-00	17-30
Settling volume for 24 hours (cc.)	9.5	100.0	9.0	31.5	30.5	22.0	11.5	225.0	132.5	137.0	112.0	30.0	137.0	21.0	3.0	26.0	(27.0) 63.0	(8.0)	9.0	2.6	18.0	6.5
Larval forms																						
Engraulis japonicus Temm. et Schl. (*Katakuchi-iwashi*)	2(5, 21)	…	…	2(7, 12)	104(7~15, A.9)	6(A.12)	2(9,9)	59(4~12, 8)	85(5~19, A.8)	1(16)	59(4~17, A.9)	81(5~8, A.8)	169(4~26, A.8)	114(4~15, A.7)	…	…	99(7~34, A.28)	22(7~57, A.32)	1(17)	…	…	…
Cololabis saira (Brevoort) (*Sanma*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	1(11.5)	…
Scomber japonicus Houttuyn (*Hon-saba*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	1(34)	…	…	…	…	…
Pseudopeneus bensasi Temm. et Schl. (*Himeji*)	…	…	…	…	…	…	…	1(21)	4(9,9, 11,7)	1(9)	2(11, 28)	…	…	…	…	…	…	…	…	…	…	…
Fugu vermicularis porphyreus (Temm. et Schl.) (*Ma-fugu*)	…	…	…	…	…	…	…	1	1(16)	…	…	…	…	…	…	…	…	…	…	…	…	…
Cypselurus opisthopterus hiraii Abe (*Hosotobi*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Cypselurus heterurus döderleini (Steindachner) (*Tsukushi-tobiuo*)	…	…	…	…	…	…	…	…	…	2(58, 127)	…	…	…	…	…	…	…	…	…	…	…	…
Coryphaena hippurus Linné (*Shiira*)	…	…	…	3(76, 77, 78)	1(97)	…	…	…	…	3(10~15)	1(14)	…	…	…	…	…	…	…	…	…	…	…
Ablennes Jordan et Fordice (*Datsu*)	…	…	…	…	…	…	…	…	…	3(17, 31, 38)	1(22)	…	…	…	…	…	…	…	…	…	…	…
Synanceiidae (*Okaze*)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Auxis Cuvier (*Sôda-katsuo*)	…	…	…	…	…	…	…	…	…	…	…	…	1(7)	5(3~6)	…	…	…	…	…	…	…	…
Chromis Cuvier (*Suzume-dai*)	…	…	…	…	…	…	…	4	3	…	…	…	…	…	…	…	…	…	…	…	…	…
…darius erodes Jordan et Fowler (*Amime-hagi*)	…	…	…	…	…	…	…	…	…	3(5)	…	…	…	…	…	…	…	…	…	…	…	…
…apoda (*Cephalopoda*) (*Ika*)	…	…	…	…	…	…	…	1(2.3)	1(25)	1(6.8)	…	2(2.0)	…	…	…	…	…	…	…	…	…	…
…ers	…	…	…	…	…	…	…	1	4	3(3)	…	1	…	6	…	…	…	…	…	…	…	…
…a larva	…	…	…	…	…	…	…	81	47	4	1	…	…	…	…	…	…	…	…	…	…	…
…ellana larva	…	…	…	…	…	…	…	1	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…alopa larva	…	1	…	…	…	…	…	12	7	2	4	…	…	…	…	…	…	…	…	…	…	…
…chyura larva	…	…	…	…	…	…	…	…	…	3	…	…	…	…	…	…	…	…	…	…	…	…
Mysis stage (*Macrura*) larva	…	…	…	…	…	…	…	378	770	…	…	…	…	…	…	…	…	…	…	…	…	…
Erichthus larva	…	…	…	…	…	…	…	2	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Alima larva	…	…	…	…	…	…	…	2	2	7	2	…	…	…	…	…	…	…	…	…	…	…
Red shrimp	…	…	…	…	…	…	…	…	…	1	…	…	…	…	…	…	…	…	…	…	…	…
Eggs																						
Engraulis japonicus Temm. et Schl.	…	…	…	…	…	…	12	…	…	…	…	…	…	21	…	…	…	3	2	…	…	…
…olabis saira (Brevoort)	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
…apoda (*Cephalopoda*)	4	7	2	1	5	6	4	…	1	…	…	1	2	5	10	5	14	1	…	…	…	…
…ers	…	…	2	…	5	1	3	…	…	1	7	2	…	4	1	…	…	…	…	…	…	…

Parenthesized numerals denote the body length, and A. denote the mode. Length of "ika" is the dorsal length of mantle.

On the Year Round Occurrence and Ecology of Eggs and Larvae of the Principal Fishes in the Japan Sea—1

by

Toshimasa SHIMOMURA and Hiroshi FUKATAKI

Contents

1. Introduction

It has already been about four years since the "Tsushima-danryu kaihatsu chosa" (General Survey on the Warm Tsushima Current) was commenced in April, 1953. As the years roll on, together with the sea conditions and the fishing conditions, the knowledge for the distribution and occurrence of eggs and larvae increased rapidly. According to the tabulation of Prof. Keitaro Uchida, in the Tsushima Current regions along the west coast of Japan (the East China Sea, the Japan Sea, and the waters west of Hokkaido), number of species of youngs captured for the past four years are 275 and that of eggs are 121. He estimates also that number of species hatched and grown up in the Tsushima Current regions probably increases many times over. Number of species obtained in the coastal waters of the Japan Sea from Yamaguchi Pref. to Aomori Pref. in eggs more than ten and in larvae about 120, each containing species of identification impossible. Of 120 larvae, "family" and what is done to identificate more closely are 107 species.

In these what come out frequently are as follows.

1 Katakuchi-iwashi … *Engraulis japonicus* Temm. et Schl.
2 Ika … Decapoda (Cephalopoda)
3 Ma-iwashi … *Sardinops melanosticta* (Temm. et Schl.)
4 Urume-iwashi … *Etrumeus micropus* (Temm. et Schl.)
5 Hon-saba … *Scomber japonicus Houttuyn*
6 Ma-aji … *Trachurus japonicus* (Temm. et Schl.)
7 Buri … *Seriola quinqueradiata* Temm. et Schl.
8 Sanma … *Cololabis saira* (Brevoort)
9 Hokke … *Pleurogrammus azonus* Jordan et Metz
10 Tobi-uo … family Exocoetidae
11 Siira … *Coryphaena hippurus* Linne
12 Soda-gatsuo … genus *Auxis* Cuvier
13 Mejina … *Girella punctata* Gray
14 Karei … order Pleuronectidae
15 Ainame … genus *Hexagrammus* (Steller) Tilesius
16 Kujime … genus *Agrammus* Günther
17 Mebaru … sub-order Sebastinae
18 Ikanago … *Ammodytes personatus* Girard

19 Kawa-hagi … order Aluteridae (Monacanthidae)
20 Himeji … order Mullidae
21 Niji-ginpo … *Dasson trossulus* (Jordan et Snyder)
22 Ma-fugu … genus *Fugu*
23 Takanoha-dai … genus *Goniistius* Gill
24 Ishi-dai … *Oplegnathus fasciata* (Temm. et Schl.)
25 Sayori … *Hemiramphus sajori* (Temm. et Schl.)
26 Datsu … genus *Albennes* Jordan et Fordice

Here the authors deal with anchovy, mackerel, yellow tail, atka-fish, and squid.

2. Method of sampling

Materials were collected by horizontal tows of "maru-chi" net* for 10 minutes at the speed of about 2.0 knots. The horizontal tows were made at the sea surface (Shimomura, 1957).

Number of year's tows are 868, that is 868 samples. Sampling was made once a month as a rule in the first decade at the fixed station since the beginning of General Survey on the Warm Tsushima Current ~~(fig. 1)~~. All of these, except Yamaguchi Pref. and Kyoto Fu, were identified by Hiroshi Fukataki, one of the authors, and the parts of Yamaguchi Pref.and Kyoto Fu were done by K. Ito (Yamaguchi Prefectural Fisheries Experimental Station) and Y. Kato (Kyoto Fu Fish. Exp. St.).

3. Acknowledgment

Here the authors express their hearty thanks to Professor of Kyushu University, Dr. Keitaro Uchida's great guidance for the identification of eggs and larvae and to many members charged with sampling of twelve prefectural fisheries experimental stations along the Japan Sea side of Honshu, from Yamaguchi Pref. to Aomori Pref.. And also the authors express hearty thanks to Miss Keiko Sakurai and Miss Masako Watanabe for helping with the identification.

Chapter I "Katakuchi-iwashi"

(Anchovy, *Engraulis japonicus* Temminck et Schlegel)

1. Preface

Number of eggs and larvae of "katakuchi-iwashi" is every year the superior among the samples captured by the surface towings of "maru-chi" net in the Japan Sea, and the occurrence period is very long, extending a whole year. So it seems that adult fishes' potential population is comparatively large.

Anchovy's annual catch in the Japan Sea, as shown in table 1, 256 by 10,000

* This net is the same as shown in figure 2 on page 140.

Table 1 Annual catch of anchovy by region and prefecture.

unit: 1,000 Kan (3.75 metric tons)

Reg. & Pref. \ Year	1951	1952	1953	1954	1955	1955/1951
Grand total	74,244	77,375	64,927	81,075	104,406	1.4
Japan Sea region	577	984	1,037	1,303	2,560	4.4
North-region	433	795	623	721	848	2.0
Aomori	0	45	0	0	5	
Akita	3	95	4	1	4	1.3
Yamagata	0	35	2	4	6	
Niigata	58	57	12	39	96	1.7
Toyama	326	513	563	606	685	2.1
Ishikawa	45	47	40	70	49	1.1
West-region	144	189	414	582	1,711	11.9
Fukui	16	19	3	42	452	28.3
Kyoto	25	31	204	129	546	26.8
Hyogo	24	2	4	5	1	0.04
Tottori	18	37	97	13	67	3.7
Shimane	2	6	35	100	243	121.5
Yamaguchi	57	92	68	291	400	7.0
East China Sea region	6,801	5,169	6,387	8,980	13,053	1.9
Pacific Ocean region	49,596	51,364	39,206	43,060	64,624	1.3
Seto Inland Searegion	13,433	13,241	13,884	22,045	19,019	1.4
Hokkaido region	3,260	5,431	4,411	5,685	5,149	1.6

(after Annual Report of Catch Statics on Fishery and Agriculture 1951—1955, Ministry of Agriculture and Forestry)

The values in 1951 are that during the period April, 1951~March, 1952 and the values for other years are all that during January to December.

kan (9,600,000 kg.) in 1955, and is only 2.5 % in grand total catch of Japan, but its relative importance is increasing yearly, as same as "ma-iwashi" (*Sardinops melanosticta* T. & S.) is.

The increasing tendency of the latest four years, since the year 1951 when completed the catch statics on fishery, is very remarkable comparing to other regions. The grand total catch in Japan increased a little in 1955 and it is only 140 per cent to that of 1951, on the contrary, that of the Japan Sea increased to 440 per cent. This increase in the Japan Sea regions is due to an expansion of production in each prefecture except Hyogo Pref., and is especially due to the great expansion of Shimane Pref. (1951 cf. 122 times) and of Wakasa Bay (Fukui Pref. and Kyoto Fu) which produced as much 30 times as that.

The occurrence of abundant eggs and larvae, namely an existence of potential spawning group,and the latest increasing tendency of the fish catch show a hopeful fact of future anchovy population in the Japan Sea. Then, it is very important to research its life history, and this paper will deal with a part the early life history of anchovy on the basis of the 868 samples of surface collecting done a whole year,

1954, by "maru-chi" net.

2. General view of occurrence of anchovy eggs and larvae

For "katakuchi-iwashi" the paper taking it up the year of 1954 as an example, describes the whole year alteration from January to December conferring other year's situation, as 1954 was a year the sampling was most practiced.

Table 2 shows the monthly occurrence of anchovy eggs by prefecture in each year during from April, 1953, when General Survey on the warm Tsushima Current was commenced, to July, 1956. Table 3 shows that of larvae. These two tables,

Table 2 Occurrence of anchovy eggs, by month and prefecture.

Region		West coast of Honshu												Hokkaido		
Year	Month \ Pref.	Yama-guchi	Shima-ne	Tottori	Hyogo	Kyoto	Fukui	Ishi-kawa	Toyama	Niigata	Yama-gata	Akita	Aomori	Japan Sea	Okhotsk Sea	Pacific
1953	4	●	●				●					○				
	5	●	●	○			●		●			○	○	○		
	6		●	●		●			●		●		○	○		
	7		○			●			●			○	○	○		
	8	●	○				○							●	●	
	9		○						○						●	
	10		○	○		○			○			○				
	11	○				●	○		○							
	12	○					○		○							
1954	1	○				○	●		○							
	2	○					●									
	3		○	○		○	●		○		○	○				
	4	○	●	●		●	●		○	○	○	○	○	○		
	5		●	○		●	●	●	●	○	●	○	○	●		
	6		●	●	●	●	●	●	●	●		○	○	●	○	
	7		●	●	●	●	●	●	●	●	●	○	○	●	○	
	8	●	●	●	●	●					○	○		●	●	●
	9	○	●	●		●	●	●	●	●	○		○			
	10		●			○	○	○	●	●			○	●	●	
	11	○				○	○	○	●	●			○	●		
	12		●			○	○	○	○	○			○	●		
1955	1		●				○		○							
	2		○			○	○	○		○	○	○	○			
	3	●	●			○	○	○	○	○	○	○	○			
	4	●	●		●	●	●	○	○	○	○	○	○			
	5	●	●	●	●	●	●	●	●		●	○	●			
	6	●	●	●	●	●	●	●	●		●	●	●	●		
	7	●	●		●	○	○	○	●	●	●	●	●	●	●	
	8	○	●	○		○	○			●	●			●		
	9		●		●		●	●	○	○		●		●		○
	10		●		○		●	○	○	○		○	○	○		
	11	○	○	○	○		○	○	○				○	○		
	12	○		○	○	○	○	○	○							
1956	1	○	○				○		○							
	2		○			○	○		○	○						
	3		○		○	○	○	○	○	○	○	○	○			
	4		●	●	●	●	●	○	○	○	○	○	○			
	5		●	●	●	●	○	○	●	●	●	●	●			
	6		●		○	●	●	●	●	●	●	●				
	7		●	●	●	●	●	●	●	●	●	●	●			

○ : Towing was made but no egg obtained.
● : Egg was obtained.

Table 3 Occurrence of anchovy larvae, by month and prefecture.

Region		West coast of Honshu												Hokkaido		
Year	Month \ Pref.	Yamaguchi	Shimane	Tottori	Hyogo	Kyoto	Fukui	Ishikawa	Toyama	Niigata	Yamagata	Akita	Aomori	Japan Sea	Ohkotsk Sea	Pacific
1953	4	●	○				○					○				
	5	●	○	●			●		●			○	○	○		
	6		○	●		●			●		●		●	○		
	7		●			●			●			●	●	●		
	8	●	○				●							●	●	
	9		●						○						●	
	10		●	●		●			●			●				
	11	●				●	●		●							
	12	●					○		●							
1954	1	○				○	●		○							
	2	○					○									
	3		○	○		○	○		○		○	○				
	4	○	●	○		○	○		○	○	○	○	○	○		
	5		●	●		●	●	○	●	○	○	○	○	○		
	6		●	●	●	●	●	●	●	○		○	●	●	○	
	7		●	●	●	●	●	●	●	●	●	●	○	●	●	
	8	●	●	●	●	●					●	●		●	●	
	9	●	●	●		●	●	●	●	●	●		●			
	10		●			●	●	●	●	●			●	○	○	
	11	●				●	●	○	●	●			○	○		
	12		●			●	○	○	●	●			○	○		
1955	1		○				○		○							
	2		●			●	●	○		○	○	○	○			
	3	○	●			●	○	○	○	○	○	○	○			
	4	●	●		●	○	○	○	○	○	○	○	○			
	5	●	●	●	●	○	●	●	●		●	○	○			
	6	●	●	●	●	●	●	●	●		○	○	○	●		
	7	●	●		●	●	●	●	●	●	●	●	●	●	○	
	8	●	●	●		●	●			●	●			●		
	9		●		●		○	●	●	○		●		●		●
	10		●		●		●	○	○	○		●	●	●		
	11	●	●	●	○		●	○	●				○	○		
	12	●		○	○	○	●	○	○							
1956	1	●	○				○		○							
	2		○			●	○		○	○						
	3		○		○	○	○	○	○	○	○	○	○			
	4		●	○	○	○	●	○	○	○	○	○	○			
	5		●	●	●	●	●	○	●	○	○	○	●			
	6		●		●	●	●	○	●	●	●	●				
	7		●	●	●	●	●	○	●	●	●	●	●			

○ : Towing was made but no larva obtained.
● : Larva was obtained.

in disregard of number of the towed stations, when egg or larva, granted it is only one organisms, is obtained somewhere on the fixed observation line, are marked with occurrence symbol (●).

By table 2 there found the next several points.

i) Time of beginning and termination of egg occurrence differ somewhat by year.

ii) Sea region of egg occurrence also differs to some extent by year and month.

iii) It is every year fixed that main spawning is limited in warm season from April to September.

iv) With the progress of years, dispersion of occurrence by month decreases, in 1956 no eggs were obtained before March.

v) From 1955 on, also in Akita Pref. and Aomori Pref. eggs have become obtained, this relates to the northing of sardine fishing grounds in recent years, namely to the remarkable strengthening of the offshore branch of the Tsushima Current since 1955. The eggs occurrence on the west coast of Hokkaido placed in farther northern region is found even before 1954, this is likely to be caused by the spawning of the wintering group in the very region and of adult riding on the offshore branch of the Tsûshima Current.

vi) Such changes as stated above are intensely due to that of the sea conditions, the authors will report in details in the near future.

Secondly, comparing table 3 (larva) with table 2 (egg), the following points are directly understood.

i) The occurrence extent of anchovy larvae by month and region is very large compared with eggs. This should originate in more or less swimming ability unlike perfectly planktonic eggs.

ii) Anchovy larvae occur mainly in warm season from May to November every year, as in the case of eggs, while both time of beginning and termination of larvae occurrence are later by a month than those of eggs.

iii) Time of beginning of larvae occurrence in 1956 is practically fixed (at present, May) like that of eggs.

3. Spawning seasons and grounds

According to the samples which twelve prefectural fisheries experimental stations placed along the Japan Sea side of Honshu captured periodically once a month a whole year of 1954, making the whole regions of the Japan Sea one, the summary of monthly occurrence condition of anchovy eggs and larvae is as shown in table 4.

As above mentioned, there found an unsuitable aspect for quantitative analysis in collecting method, and also, number of stations at which towings were made does not always equal every month (i.e. because of the weather condition and a ship mending), but as a tendency, there found the next several points by table 4.

i) Anchovy keeps on its spawning a year round somewhere in the Japan Sea, provided aside its quantity from problem.

ii) But quantitative abundance of spawned eggs is limited in warm season from April to October, the best season is June.

iii) The quantity decreases gradually from July on, and on the contrary it increases a little in October again, but that of spawning in this autumn season is very small compared with that of spring.

iv) In general, the larvae occur later than eggs and the best season is July.

The positions of stations at which tows were made, and the occurrence of anchovy

Table 4 Monthly occurrence of anchovy eggs and larvae in 1954.

Month	A No. of total sts., at which towings were made	Egg B No. of sts., at which eggs were obtained	Egg C Number	Larva D No. of sts., at which larvae were obtained	Larva E Number	B/A (%)	C/A	D/A (%)	E/A
Total	864	165	24,994	282	26,754	19.1	29.0	32.6	30.9
Jan.	37	2	8	1	1	5.4	0.2	2.7	0.03
Feb.	29	1	1	0	0	3.4	0.3	—	—
March	77	1	1	0	0	1.3	0.1	—	—
April	122	9	2,259	8	136	7.4	18.5	6.6	1.1
May	106	18	4,058	29	1,003	17.0	38.3	27.4	9.7
June	80	36	12,854	31	1,147	45.0	161.0	38.8	14.4
July	100	35	3,258	66	19,806	35.0	32.6	66.0	198.1
Aug.	63	18	541	42	3,331	28.6	8.6	66.6	52.9
Sept.	91	28	315	31	461	29.2	3.5	32.3	5.1
Oct.	66	14	1,696	49	795	21.2	25.7	74.3	12.1
Nov.	44	1	1	15	51	2.3	0.0	33.8	0.9
Dec.	49	2	2	10	23	4.1	0.1	20.4	0.5

eggs and larvae are illustrated in figures 1~22. The followings are the summary of these.

January~March (figs. 1~4) :

Owing to winter season, prevailing north-westerly monsoon, collecting regions during this period are limited. The spawning in the Japan Sea can not be confirmed, but there found a little spawning in the wintering population in Wakasa Bay. In January no larva can be seen through February to March along the neritic waters in the Japan Sea, except one, 20 mm. in total length, in offshore region of Wakasa Bay, so it is doughtful whether larvae laid in this winter season can keep their growing or not.

According to Annual Report of Catch Statics on Fishery, in winter season, total twelve months, during nine months of them, north end of anchovy's landing is Toyama Pref.. Thus it is estimated north end of adult anchovy distribution in

Geographical distribution of anchovy eggs and larvae in the Japan Sea. January~December,1954. (figs.1~22).

The following symbols designate the number of eggs and larvae

Symbol	No. of eggs	No. of larvae
○ :	0	0
◔ :	1-10	1-10
◑ :	11-100	11-50
◕ :	101-1,000	51-100
● :		101-1,000
⬤ :	Over 1,001	Over 1,001

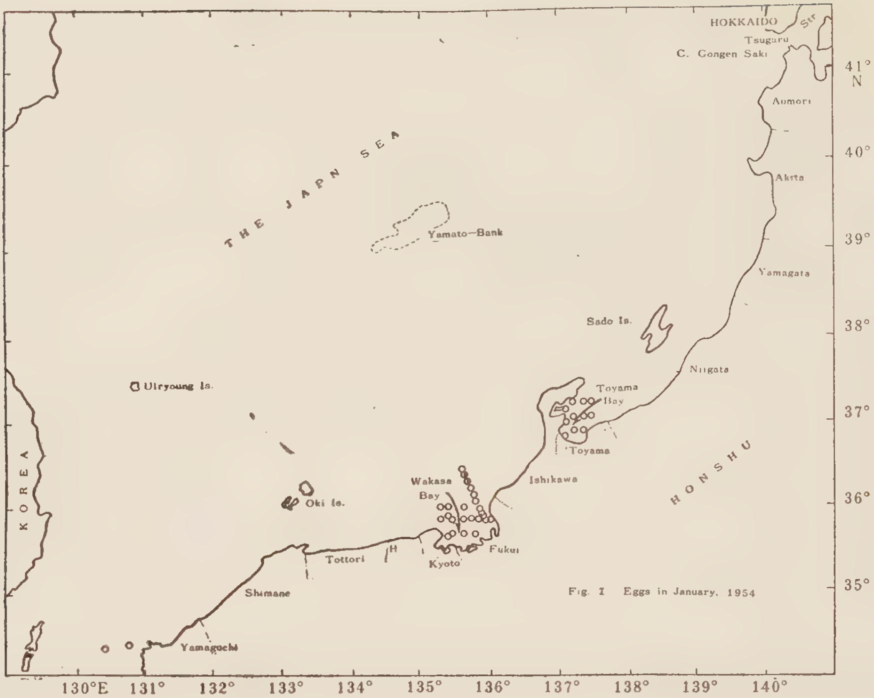


Fig. 1 Eggs in January, 1954

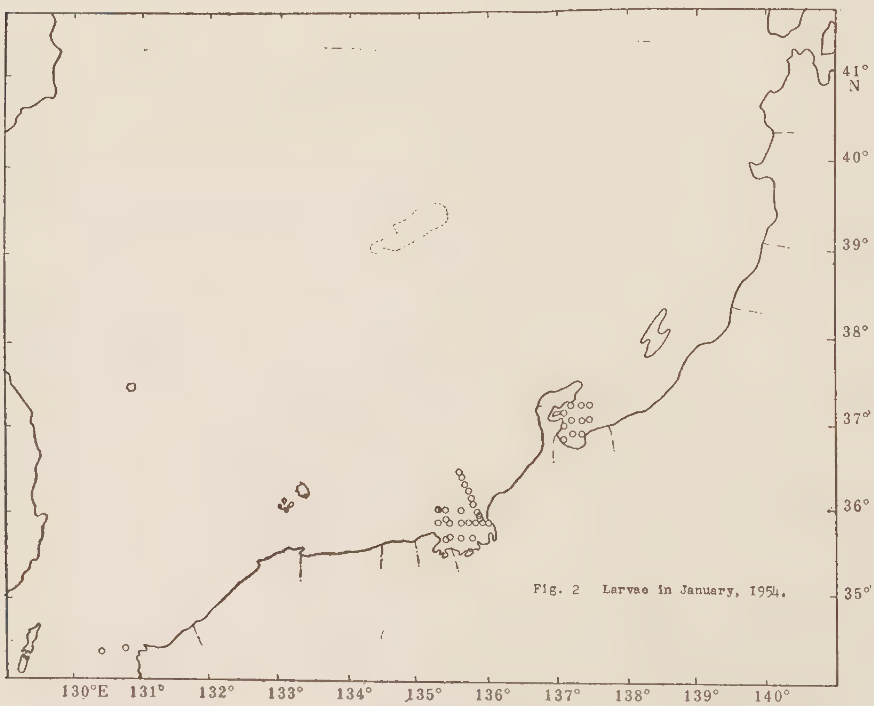


Fig. 2 Larvae in January, 1954.

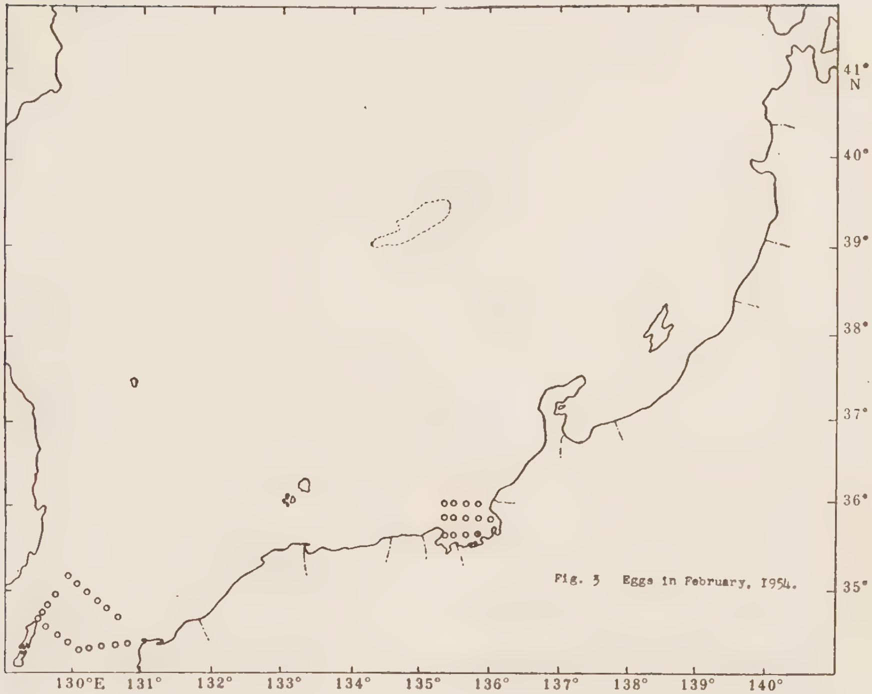


Fig. 3 Eggs in February, 1954.

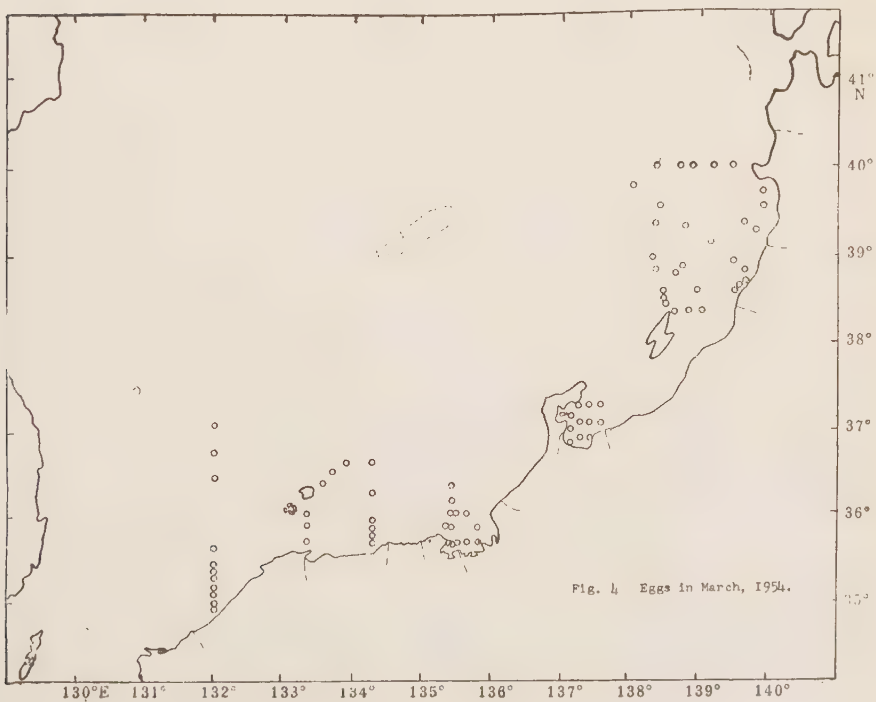


Fig. 4 Eggs in March, 1954.

winter is Toyama Bay. While during the same winter season in three years from 1954 to 1956, no larvae and eggs of anchovy can be found for total eight months. So it is estimated that larger body length group (total length more than 100 mm.) of winter season does not spawn in Toyama Bay calling the wintering grounds of the northern-most limits in the Japan Sea (fig. 27).

According to Yokota (1953), Kawamura (1955), Nakai (1955), and Yokota & Asami (1956), on north and west coast of Kyushu, in Hyuga Nada, and south of middle part along the Pacific side of Honshu, anchovy keeps on its spawing in every season, there can be seen a tendency of quantitative increasing of spawning from January to March. It contrasts to the case of the Japan Sea. The environmental factor is estimated the lower temperature in the Japan Sea as one of the chief causes. For example, in Hyuga Nada, February, the lowest water temprature period of a year, is 18°C. level by the sea surface and 8°-11°C. in Toyama Bay in the Japan Sea.

April (figs. 5,6):

As the north-westerly monsoon in winter is going down gradually in April, number of stations at which towings were made becomes increased and also number of eggs grows with rise of water temperature accompanied with the beginning of mighty northing of the Tsushima Current (table 1), especially dense distribution of eggs can be seen in the inner-most part of Wakasa Bay. But occurrence regions of eggs are limited in the neritic regions west of Wakasa Bay, no eggs are completely

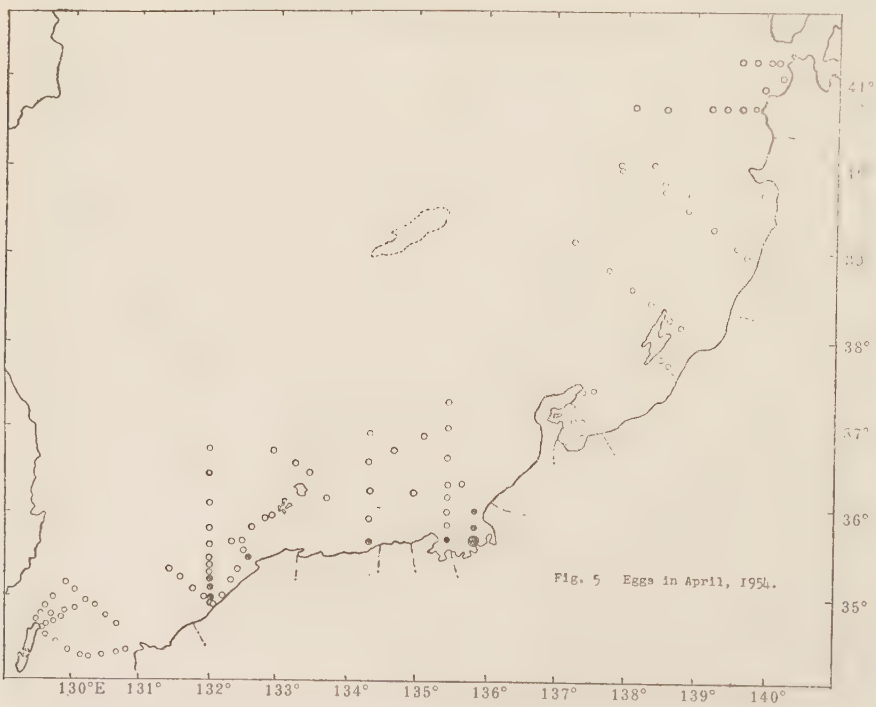


Fig. 5 Eggs in April, 1954.

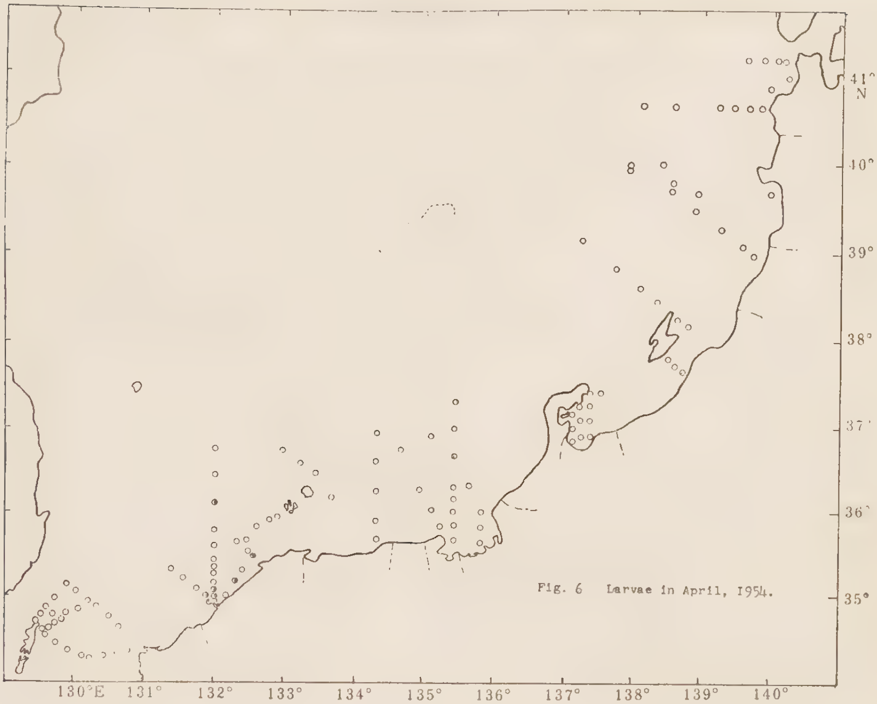


Fig. 6 Larvae in April, 1954.

obtained north of Toyama Bay and in the offing west of Wakasa Bay.

Thus after this month, anchovy begins its laying actively and it is estimated the region is limited in the west neritic waters of the Japan Sea.

Occurrence of larvae is limited in the coastal region of Shimane Pref., and no larvae in Wakasa Bay.

May (figs. 7,8) :

At the beginning of May, north limits of eggs distribution comming up to the west coast of Yamagata Pref., the dense distribution region of eggs is found in the eastern part of Wakasa Bay and in Toyama Bay. It is estimated by this fact, wintering larger-body-length group in Toyama Bay (13° C.) begins its spawning in May.

North end of larvae distribution is in Tayama Bay at early May, and according to the towings of Hokkaido Reg. Fish. Res. Lab., toward the end of May it comes up to offshore of Gongen Saki of Aomori Pref., also spawning region getting to north swiftly. This is an an interesting phenomenon corresponding to the sea conditions of May when water temperature is rising most quickly in year.

Occurrence regions of larvae in western part of the Japan Sea extend more offshore than the eggs distribution in April and May. This fact shows not only arvael get their swimming power with their growth but also they correspond to the increasing in energy of the offshore branch of the Tsushima Current.

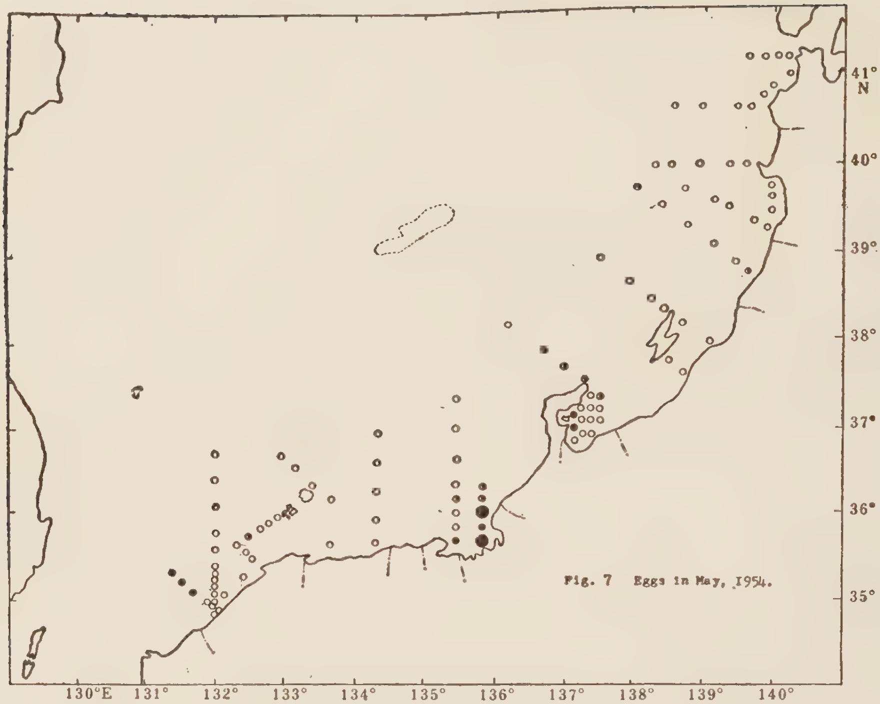


Fig. 7 Eggs in May, 1954.

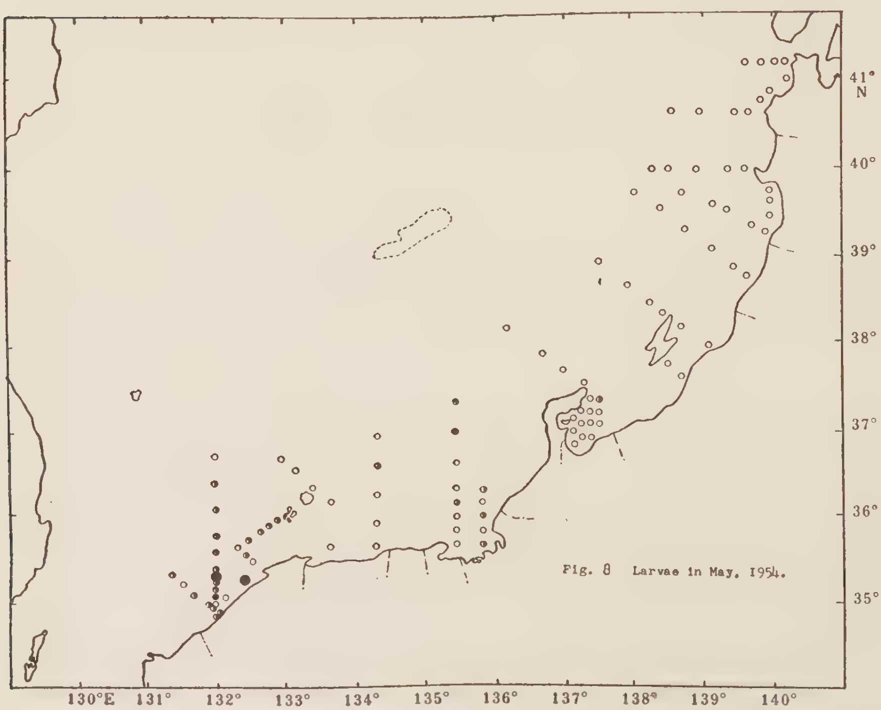


Fig. 8 Larvae in May, 1954.

June (figs. 9,10) :

The north end of eggs distribution reaches around Okushiri Is., Hokkaido, at the middle of June and reaches Ishikari Bay toward the end of June (Hokkaido Reg. Fish. Res. Lab.). No eggs can be seen in Aomori district and sampling is not practiced on the coast of Akita Pref. and Yamagata Pref., but at the beginning of this month there found dense distribution in Wakasa Bay (western part) and all parts of Toyama Bay, and also in Ishikari Bay at the end of June.

As it is clear by the ratio of number of stations, at which eggs were obtained in net, to number of total stations, at which tows were made, and by number of organisms per tow shown in table 4, June shows the highest value. Thus it can be estimated that June is the best season for laying in main spawning grounds of anchovy—Wakasa Bay, Toyama Bay, and Ishikari Bay.

One of the remarkable facts in eggs distribution in June is occurrence of eggs, scanty as it is, in south-west of Yamato Bank placed in central part of the Japan Sea, namely the spawning in offshore branch of the Tsushima Current. Eggs and larvae were captured in the offing beyond the Liman Front by the authors in investigation of August, 1955 and of August and September in 1956 (Shimomura, unpublished).

A relative dense distribution of larvae can be seen in the western entrance to the Tsugaru Strait, in Toyama Bay, and on the coast of Shimane Pref..

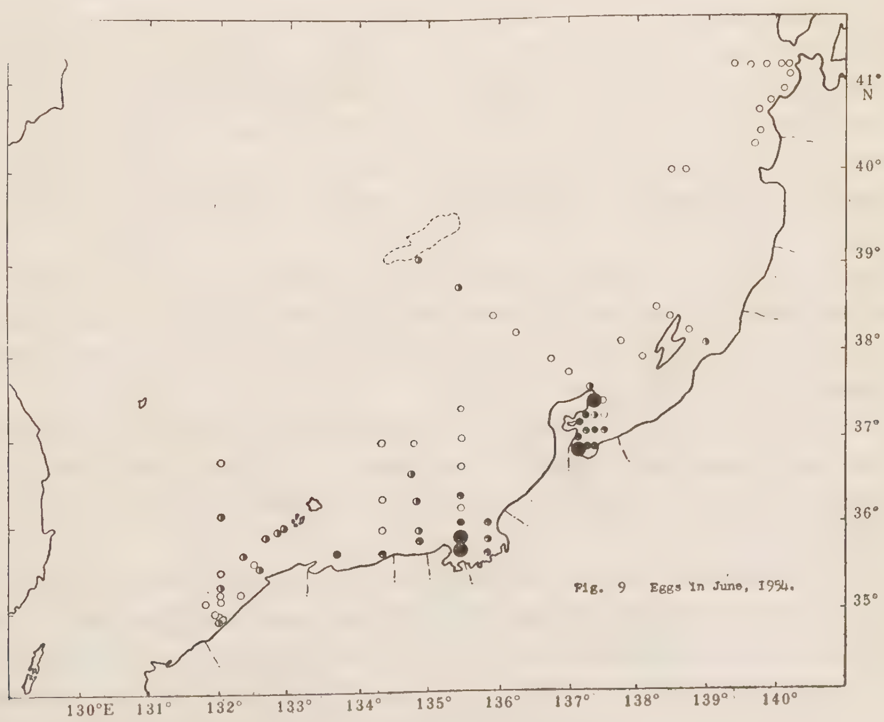


Fig. 9 Eggs in June, 1954.

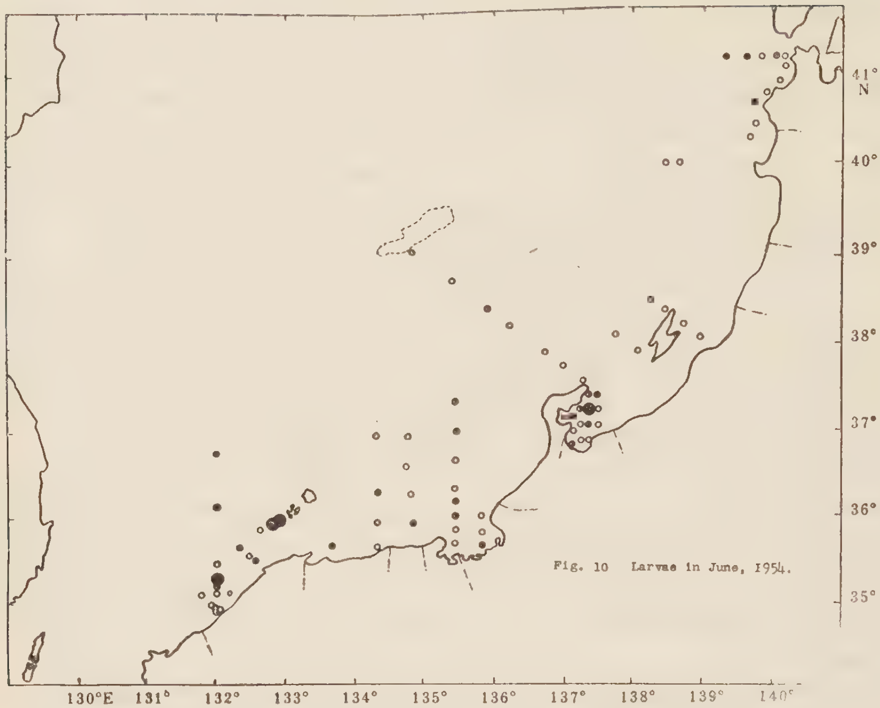


Fig. 10 Larvae in June, 1954.

July (figs. 11,12) :

In July, towings with "maru-chi" net were made in expanded offshore region for researching the sea conditions, getting six pref. fish.exp. sts. north of Ishikawa Pref. more out offshore than usual month does. But no eggs were captured in this expanded region; the ratio of number of stations, at which eggs were obtained, to number of total stations, at which tows were made, is less outwardly than in June (table 4).

According to the data from Hokkaido Reg. Fish. Res. Lab., anchovy's eggs distribution, already at the beginning of July, reaches the Okhotsk Sea beyond the Soya Strait from the west coast of northern Hokkaido and north end of the distribution shows a going north than in June.

On the Japan Sea side of Honshu, it is estimated that eggs occur throughout the whole area as in June, but number of total eggs is remarkably less than in June. On the other hand, still a dense distribution can be found in the inner-most part of Toyama Bay.

In larvae distribution in July, the percentage of stations, at which larvae were obtained, to number of total stations, at which tows were made, and also number of larvae per tow show the highest value in a year round (table 4) ; it ranks with the best spawning season of June. The north end of distribution regions of larvae is placed in Akita Pref.; no larvae almost completey occur in offshore of Aomari Pref.;

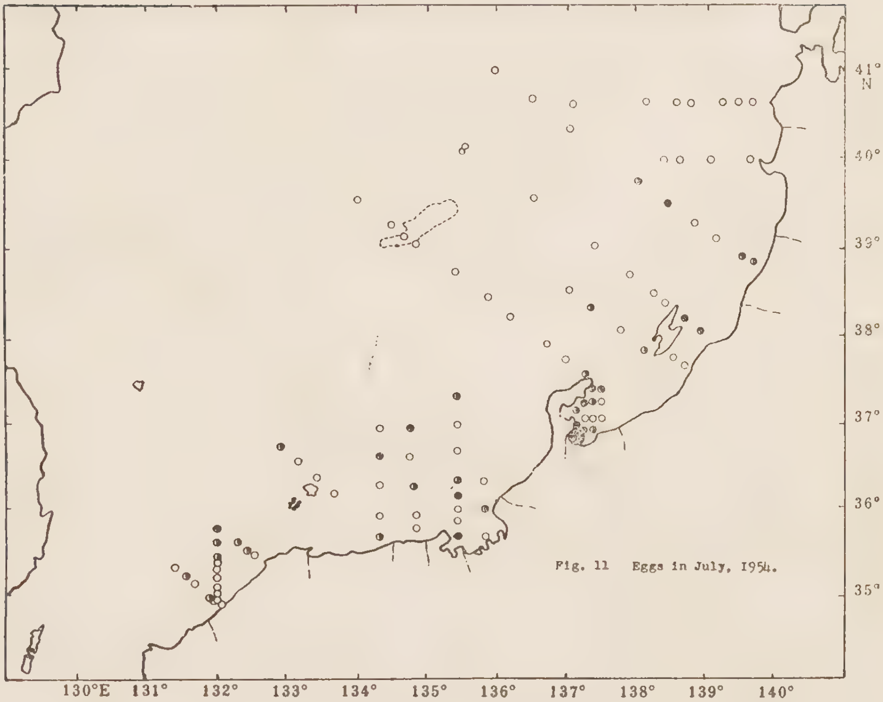


Fig. 11 Eggs in July, 1954.

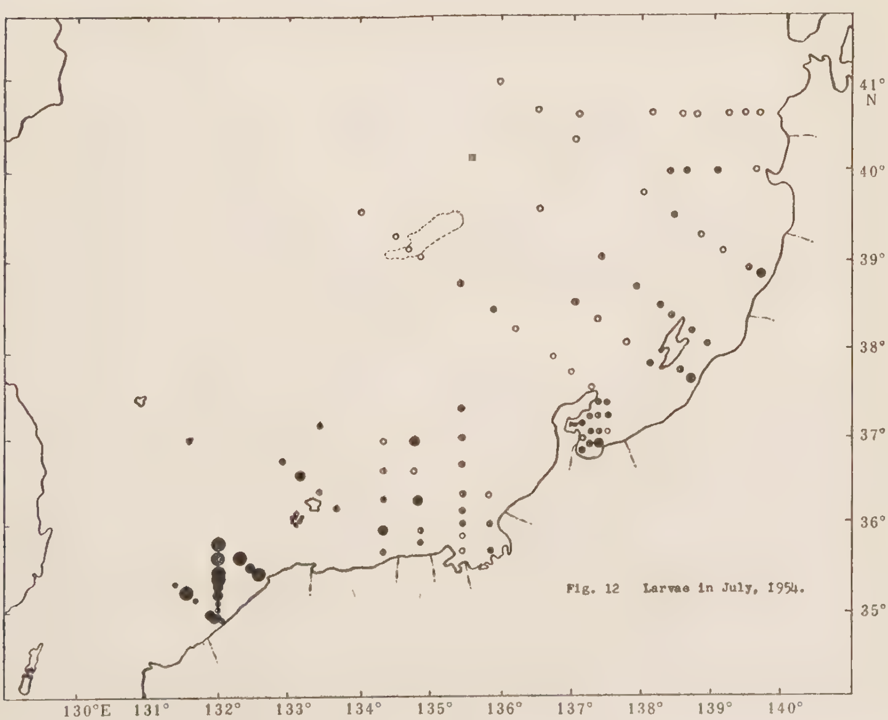


Fig. 12 Larvae in July, 1954.

and the neritic waters of Hokkaido. Larvae occur late in time and geographically compared with occurrence of eggs. In south of Akita Pref. there can be found its occurrence throughout the whole area, especially the distribution in the neritic region of Shimane Pref. is dense.

From a view point of the sea conditions, it is naturally estimated, in the southern Japan Sea both eggs and larvae will distribute in more offshore region than the present investigation region. In the northern Japan Sea the tendency that the distribution of eggs and larvae divide into two, one is in offshore and the other is in neritic region, can be seen.

August (figs. 13,14) :

In this month many research vessels are in dock for the sake of periodical inspection, there are many blanks in researching water regions.

Considering data from Hokkaido Reg. Fish. Res. Lab. and from August in 1955 (Shimomura, 1957), the spawning regions have no differences during August to July, and anchovy spawn widely through all regions of the Japan Sea and the Okhotsk Sea, but number of eggs is less than in July generally.

The distribution region of larvae is almost like that of eggs and it is clear that larvae distribution extends over more offshore region, by research in August, 1955 (Shimomura, 1957) and by research during August and September in 1956 (Shimomura, unpublished).

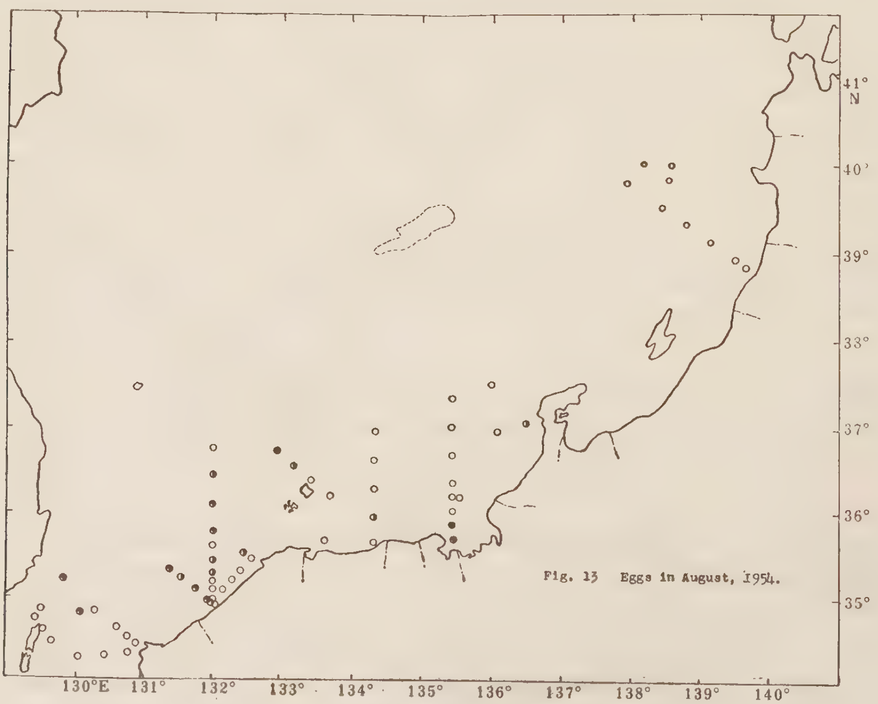


Fig. 13 Eggs in August, 1954.

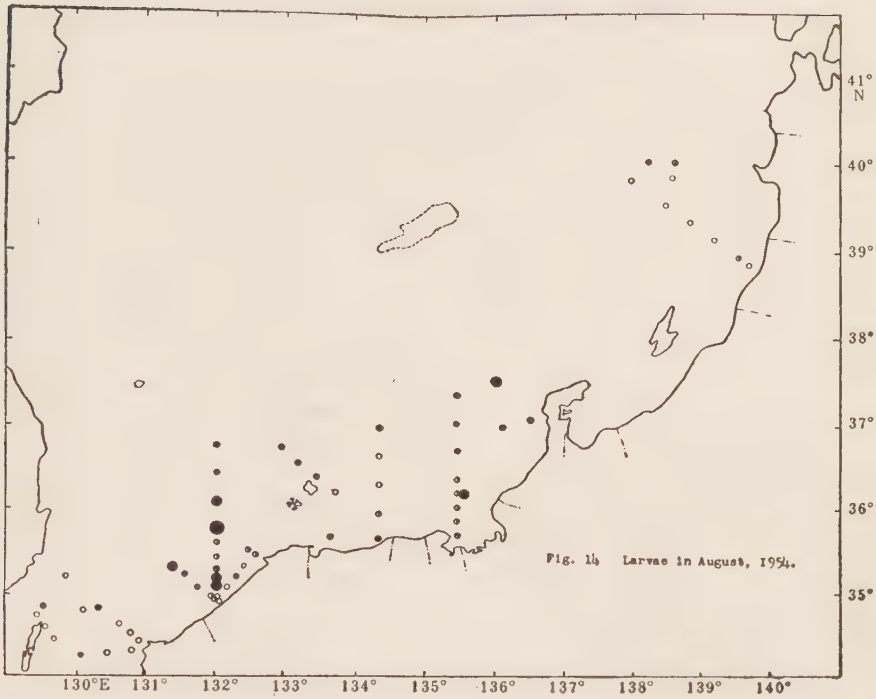


Fig. 14 Larvae in August, 1954.

September (figs. 15,16) :

The north end of occurrence of eggs lies in offshore of Sado Is.—in this month no towing was made around Hokkaido—, wide distribution regions up to August begin to become narrow; no dense distribution regions of eggs can be seen anywhere, number of spawned eggs seems to decerease from August on.

Larvae distribution can be found in offshore region, in the northern Japan Sea and they occur in all regions under investigation, in the southen Japan Sea. It is estimated that larvae distribution expands in farther offshore region from the point of the author's investigation in September, 1956.

October (figs. 17,18) :

As mentioned previously, number of eggs and larvae per tow is larger than in September (table 4). This increase is not due to that throughout the whole regions (the percentage of number of stations, at which eggs were obtained, to number of total stations, at which tows were made, is lower than in September) but chiefly due to appearance of dense distribution in Toyama Bay.

The north end of eggs distribution is as same as last month. In this month, Hokkaido Reg. Fish. Res. Lab. made towings on the Japan Sea side of Hokkaido and in the Okhotsk Sea, no eggs in net except a few larvae obtained. In the southern Japan Sea no eggs occur even in Wakasa Bay and only a few eggs can be seen particularly on the northern coast of Shimane Pref.. Thus at least in 1954 it is

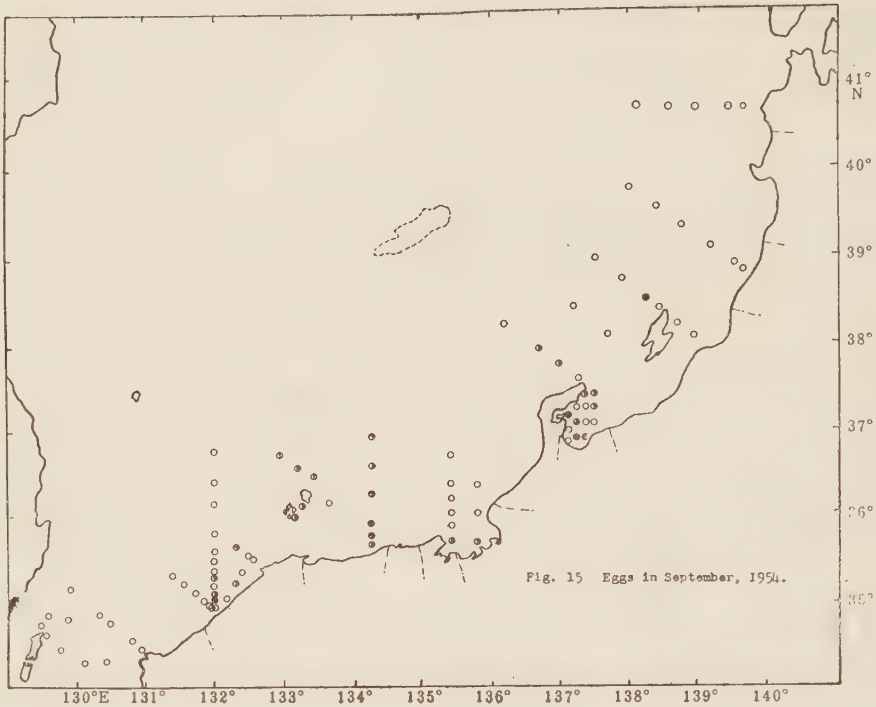


Fig. 15 Eggs in September, 1954.

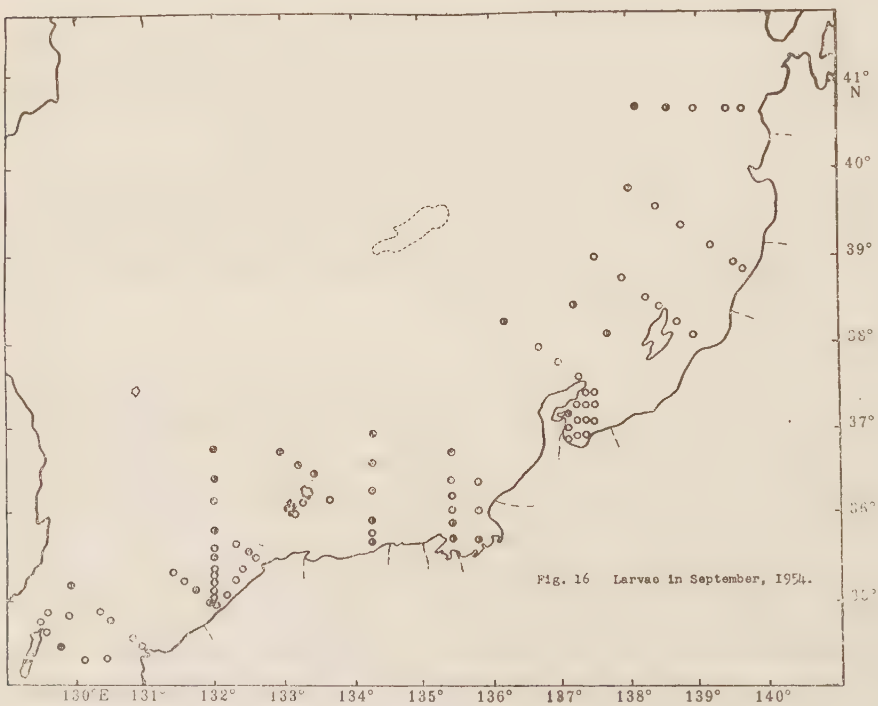


Fig. 16 Larvae in September, 1954.

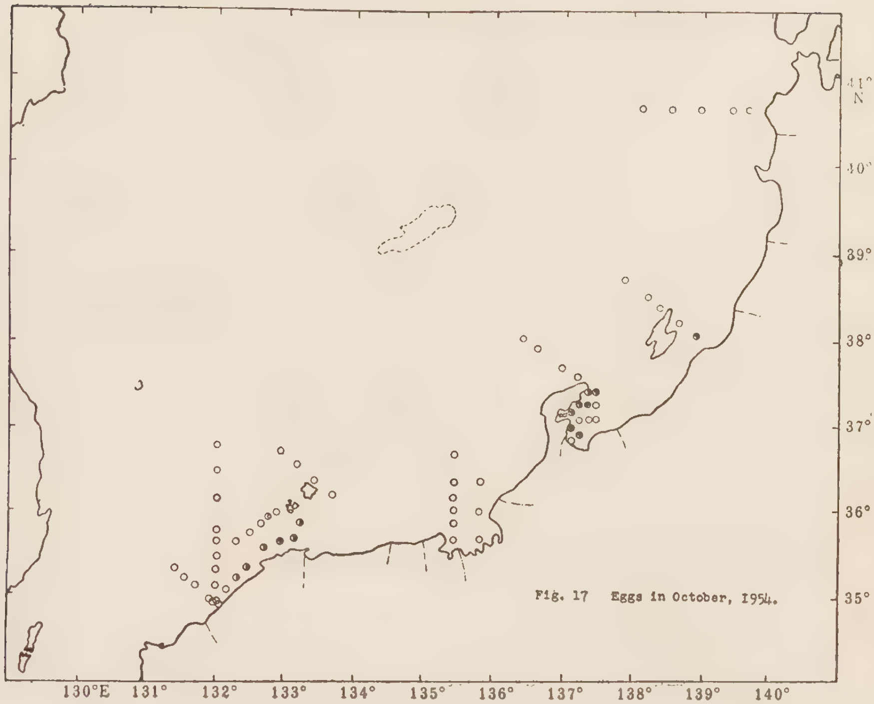


Fig. 17 Eggs in October, 1954.

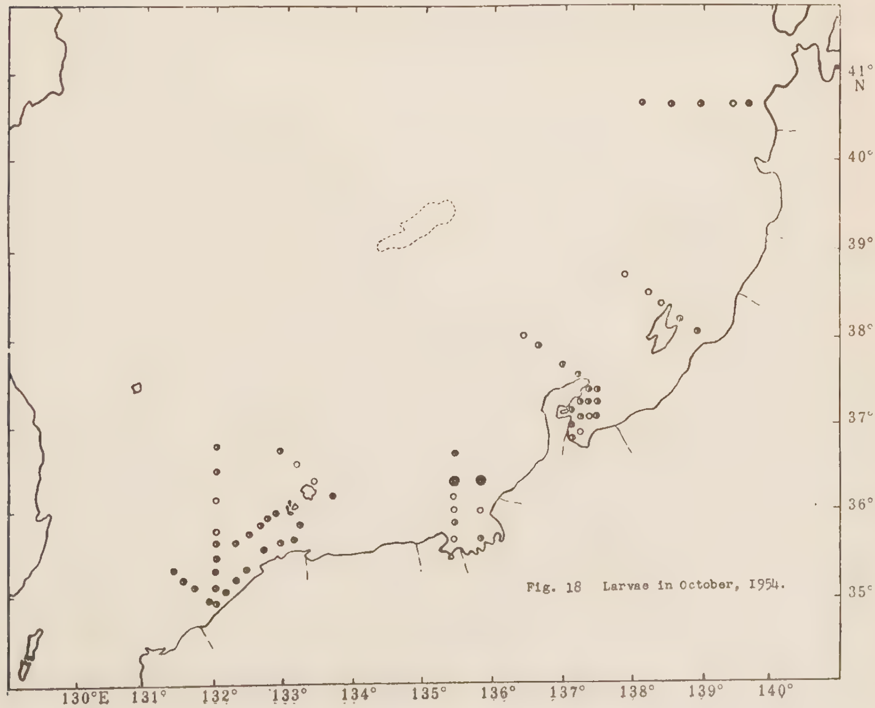


Fig. 18 Larvae in October, 1954.

doubtful to exist autumn hatch group in the Japan Sea region (Watanabe, 1955), it should be estimated only in very limited region anchovy keeps its autnmn spawning.

Larvae, as stated above, occur a few in wide region extending Shimane Pref. to Hokkaido. But, in this month, number of organisms is few except in Wakasa Bay. It shows something a late phenomenon in time and in place comparing with occurrence of eggs like a going north of distribution-north-limits from spring to summer.

November~December (figs. 19~22) :

No eggs can be seen in these months except one captured in Toyama Bay in November, and in December captured two eggs in the coastal water of Shimane Pref., that is, it should be estimated the spawning comes on end.

Larvae occur in Ishikari Bay in November and in offshore of Sado Is. in December as the north limits, respectively. But they are only traces, and their body length is rather large (total length is 20 mm. or over).

4. Relation between the occurrence of eggs & larvae and the sea conditions

1) Relation to surface water temperature

The whole year range of surface water temperature throughout all stations, at which surface tows with "maru-chi" net were made, is 6°~27°C., temperature range when anchovy eggs were obtained is 10°~27°C., that of larvae is 13°~27°C.. They are fairly eurythermal and also curyhaline. It is estimated the minimum water

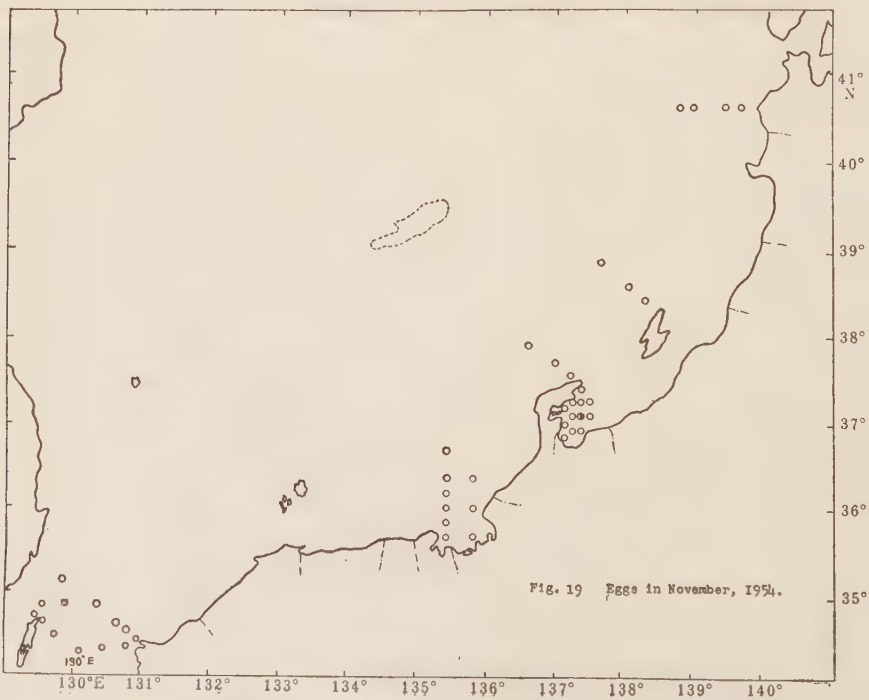


Fig. 19 Eggs in November, 1954.

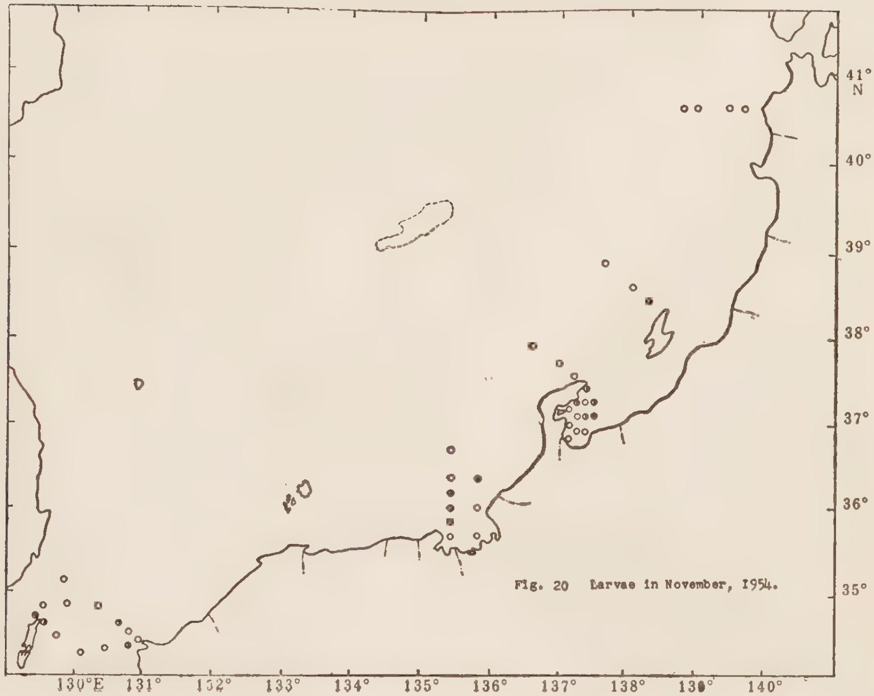


Fig. 20 Larvae in November, 1954.

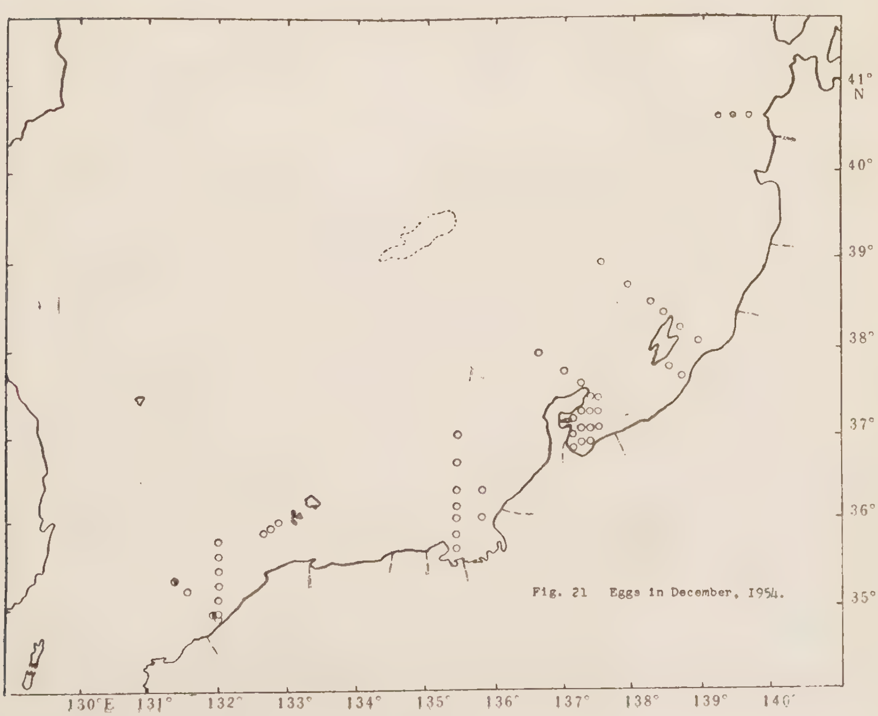


Fig. 21 Eggs in December, 1954.

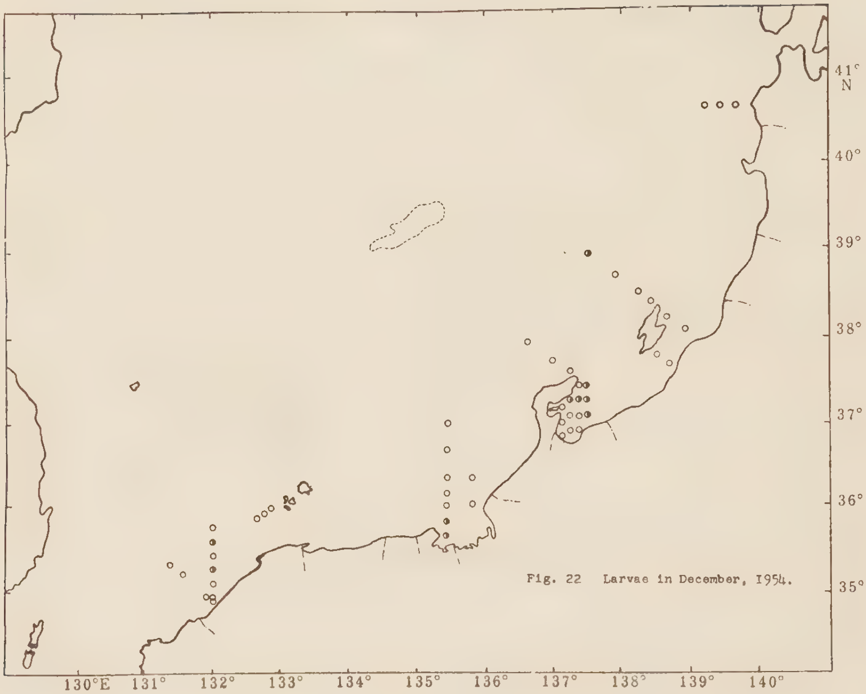


Fig. 22 Larvae in December, 1954.

temperature as a limiting factor for living anchovy is 9°-10°C. by the distribution of matured anchovy in winter season. As mentioned previously, this seems to decide the north limits of distribution on the Japan Sea side and the Pacific side during winter season.

Like this, the minimum of water temperature range when eggs were obtained is 10°C., but number of eggs captured is very few in the range from 10°-12° C., on the other hand the minimum range for larvae occurrence is 13°C.. So that the minimum temperature for effective reproduction of anchovy is estimated 13°C..

The maximum of water temperature range at all stations, at which tows were made, and at stations, at which anchovy eggs and larvae were obtained, is all equal 27°C.. It is estimated there is no the upper limits of water temperature in the Japan Sea as a limiting factor, because it does not rise even in summer more than 28°C..

For observing the optimum temperature in spawning season, the ratio of number of stations, at which eggs or larvae were obtained, to number of total stations, at which towings were made, and number of organisms per tow in every water temperature range are given in figures 23 a and 23 b.

Observing the ratio of number of stations, at which eggs and lavae were obtained, eggs are bimodal and they show mode at 20°C. and about 24°C., while larvae show monomodal type, having mode at 22°C.. But number of organisms per tow, both eggs and larvae are monomodal and inclination shown in figures 23 a, b is steeper than

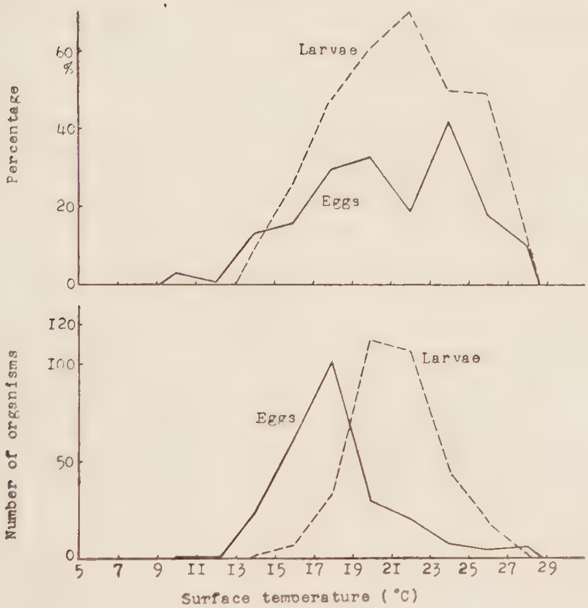


Fig. 23 a (Upper) The ratio of the number of stations, at which eggs or larvae were obtained, to the number of stations towed, by surface water temperature.

Fig. 23 b (Lower) The number of eggs and larvae per tow by surface water temperature.

the ratio of number of stations; eggs mode is 17°~18°C. and that of larvae is 19°~20°C.. Namely, the optimum temperature for spawning and growth of larvae ranges from 17° to 24°C..

2) Relation to surface chlorinity

A whole year range of surface chlorinity at all stations, at which towings with "maru-chi" net were made, is very wide extending 11–19.4 ‰, owing to few stations got influence from the rivers. While the range of surface chlorinity at stations where eggs or larvae were obtained is 15 ‰ level in their lower limits both in eggs and larvae. The maximum of eggs is 19.3 ‰ level and is 19.2 ‰ level in larvae. The ratio of number of stations, at which eggs and larvae were obtained, to number of total stations, at which towings were made, and number of organisms per tow for several chlorinity ranges are given in table 5. By table 5 it is observed anchovy is an euryhaline in both spawning period and growing period of larvae. From this fact it is clear that dense distribution of eggs and larvae can be seen in very low salty waters; consequently it should be unsuitable to request the limiting factor found in water temperature into chlorinity.

Above mentioned deals with a matter of whole spawning period of anchovy and of averaged monthly aspect of them. Table 6 and figure 24 show the mean surface water temperature and mean surface chlorinity of all stations, at which towings were made, and them of stations, at which eggs and larvae were obtained, for seven months from April to October when considered main spawning season.

Clearing from figure 24, in April and May some discrepancies are seen between the mean water temperature and chlorinity of all stations towed and those of the stations at which eggs and larvae were obtained. This shows, in the spring season, surface water of the southern Japan Sea is higher in temperature and in chlorinity than that of the northern Japan Sea, and, on the other hand, in those two months, anchovy's spawning does not yet extend to the whole regions in the Japan Sea. Mean deviation at stations, at which larvae were obtained, from mean value of total stations, at which towings were made, is larger than that of eggs in these two months; this corresponds to

Table 5 Occurrence of anchovy eggs and larvae, by surface chlorinity, in tows made during 1954.

Chlorinity range (‰)	A No. of total sts., at which towings were made	Egg: B No. of sts., at which eggs were obtained	Egg: C Number	Larva: D No. of sts., at which larvae were obtained	Larva: E Number	B/A (%)	C/A	D/A (%)	E/A
Total	864	165	24,994	282	26,754				
11—	1	0	0	0	0	—	—	—	—
12—	0	0	0	0	0	—	—	—	—
13—	1	0	0	0	0	—	—	—	—
14—	1	0	0	0	0	—	—	—	—
15—	3	1	2,246	2	161	33	749	67	54
16—	6	2	19	2	460	33	3	33	6
17—	77	24	1,307	34	2,438	31	17	44	32
18—	514	102	18,335	181	21,548	20	36	35	42
19—	196	29	2,933	49	823	15	15	25	4
unknown	65	7	154	14	1,324				

Table 6 Average surface water temperature and chlorinity of the total stations towed and the stations at which anchovy eggs or larvae were obtained in 1954.

Month	Average temperature (°C.)			Average chlorinity (‰)		
	A Total sts at which towings were made	B Sts. at which eggs were obtained	C Sts. at which larvae were obtained	A	B	C
Jan.	13.5	14.0	14.5	18.86	18.80	18.95
Feb.	13.6	10.5	—*	19.01	18.55	—*
March	10.8	10.5	—*	18.70	18.15	—*
April	13.0	14.4	14.9	18.87	19.06	19.16
May	14.3	15.4	17.1	18.84	18.97	19.08
June	17.1	17.7	17.5	18.81	18.81	18.84
July	19.9	20.4	20.5	18.62	18.54	18.54
Aug.	25.0	25.3	25.0	18.00	17.93	18.04
Sept.	25.2	24.9	24.9	18.11	18.07	18.11
Oct.	20.9	21.1	20.8	18.45	18.37	18.43
Nov.	19.0	18.5	19.4	18.64	18.55	18.61
Dec.	16.5	17.5	17.0	18.69	18.91	18.70

* In February and March no ~~eggs and~~ larvae were obtained.

the fact that larvae occurrence is later than eggs occurrence in time and place. No remarkable deviation can be seen in these three values during the period from June to October as being found them during from April to May; water temperature

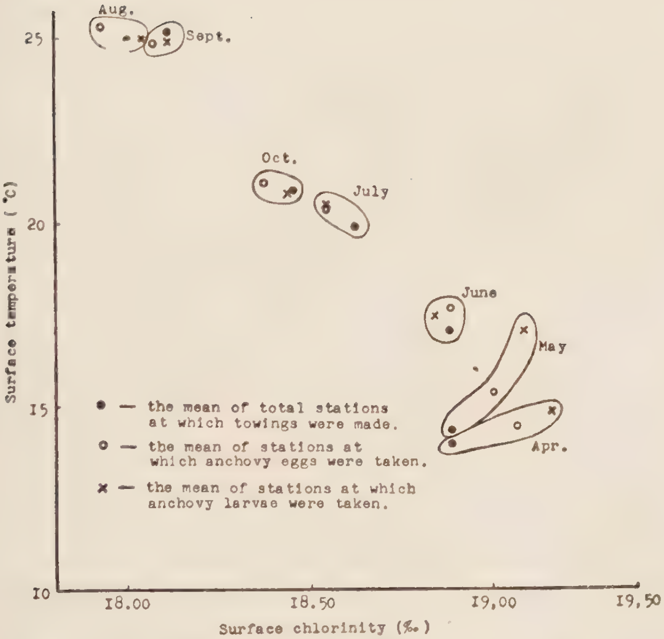


Fig. 24 Climograph showing the occurrence of eggs and larvae.

and chlorinity have no effect on anchovy's spawning and on growth of larvae as dominant limiting factors and eggs are in general laid throughout the whole regions of the Japan Sea.

The temperature of the surface water of the Japan Sea becomes higher swiftly after spring—this evidently in May—and the chlorinity shows a rapid fall from June on, owing to the beginning of the mighty northing of the Tsushima Current, the inflow of the low salty water originated in the China continent into the Japan Sea, melted snow and "bai-u" (rain in the wet season, June). And it becomes the highest temperature and at the same time shows the lowest chlorinity in a year round in August and September. In October, the temperature descends again, showing value of July and the mean water temperature and the mean chlorinity of stations, at which eggs and larvae were obtained, change also corresponding to such a condition. Namely, it is clear that anchovy's eggs and larvae are very eurythermal and euryhaline.

But as above mentioned, the best spawning season is June and decreases from July on, and some increases in limited region can be seen in October again. On aspect of the sea conditions, it is very interesting to observe a period variation of such a water temperature and chlorinity.

3) **Occurrence condition of eggs and larvae by time**

Any special investigation by above title has not been made but arrange by time, the results of 1954, is shown as in table 7. It is generally known that anchovy's spawning have a center in the night (20 to 23 o'clock) (Nakai, 1955) and larvae make a vertical, diurnal migration. But in table 7, it can only be observed that number of eggs is larger in the daytime than in the night and that the ratio of number of stations, at which larvae were captured, to number of total stations, at which towings were made, is larger in midnight (20-03 o'clock) than other time. This is an apparent phenomenon for covered the factor by time, owing to the factors as follows; it is necessary to clear this problem a special investigation.

a) Research vessels put out to the sea usually in the morning, so the daytime

Table 7 Occurrence of anchovy eggs and larvae by time in towing made during 1954.

Time	A No. of total sts., at which towings were made	Larva B No. of sts., at which larvae were obtained	Larva C Number	Egg D No. of sts., at which eggs were obtained	Egg E Number	B/A (%)	C/A	D/A (%)	E/A
Total	864	282	26,754	165	24,994	33	31.0	19	28.9
00:00-03:59	56	25	1,463	8	140	45	26.1	14	2.5
04:00-07:59	109	33	3,392	27	1,042	30	31.1	25	9.5
08:00-11:59	229	58	3,642	49	8,824	25	15.9	21	38.5
12:00-15:59	245	85	8,892	53	13,210	35	36.2	22	53.8
16:00-19:59	144	47	8,733	21	1,701	33	60.6	15	12.8
20:00-23:59	69	31	468	6	41	45	6.8	9	0.6
unknown	12	3	160	1	36	25	13.3	8	3.0

towing is made in the neritic regions, night towing offshore regions.

b) In the coastal regions an interval between stations towed is short (2 to 5 nautical miles) and it becomes longer with its going off (20 to 30 nautical miles).

c) Distribution of eggs and larvae are dense usually in the coastal region.

For the above-mentioned factors, both the ratio of number of stations, at which organisms were obtained, to number of total stations, at which towings were made, and number of organisms per tow are seemingly more abundant in the day than night.

5. Maturity of gonad and spawning

In Data from Survey of "Iwashi" Resources in Japan Sea (Ser. B, 1951-1954) and Data from Survey of "Iwashi" Resources in the Pacific Area of Honshu (Ser. B, 1951-1954) gonad weight was measured only from April to December in Wakasa Bay and from June to August in Mutsu Bay, Aomori Pref.. On the basis of these measurement records, provided calculates gonad index$\left(=\frac{\text{gonad weight (gr.)}}{\text{body length}^3\text{ (mm.)}}\right)$ and frequency by monthly gonad index, its seasonal variation is shown in figure 25. No adult with immature gonads is included in this figure (in Wakasa Bay less than 80mm., in Mutsu Bay less than 100 mm.).

Observing Wakasa Bay region, gonad index of April and May is monomodal making mode 6 to 7, it shows the highest index during the research period and seems to show the spawning of prosperity. In June, mode disappears, the percentage of organisms estimated at least spawned once besides under the spawning increases. (Aikawa (1954) reported anchovy is multiparacity). Moreover percentage of a light weight gonad increases during from July to September, and the organisms that gonad can not be measured occupy the majority during the period from October to December.

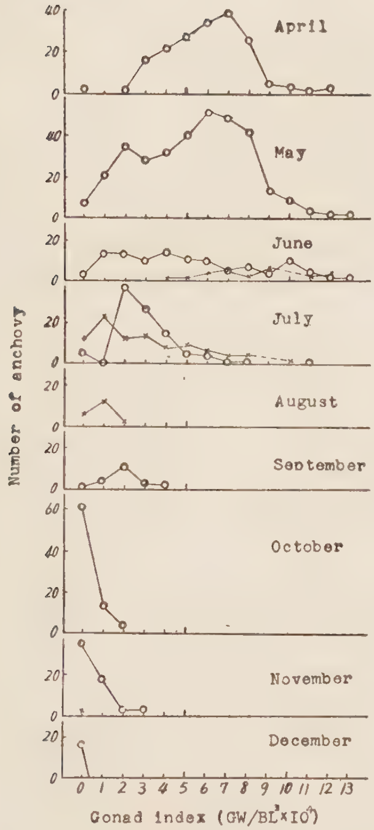


Fig. 25 Monthly frequency of anchovy by gonad index.

-O- : Wakasa Bay
-×- : Mutsu Bay

No data of anchovy found in Mutsu Bay, except only June-August and a little anchovys to be measured, but the spawning can be seen in June and seen number of adults after spawning increases in July and August.

Figure 26 shows what calculated

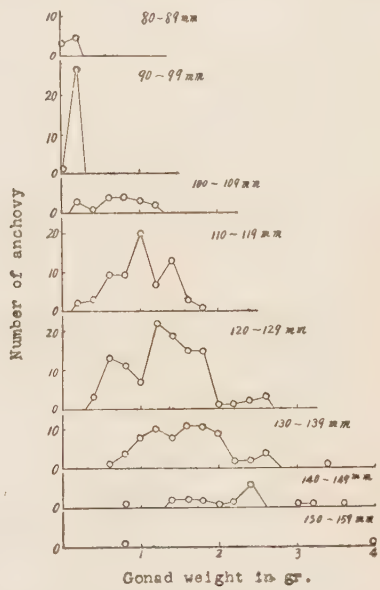


Fig. 26 Gonad-weight frequency in each body-length group in May of Wakasa Bay.

frequency by gonad weight of each length group about May in Wakasa Bay, in which there expected many anchovys under spawning in figure 25. Aikawa (1954) reported that, on the basis of the data taken from fishing grounds around northern Kyushu and Ehime Pref., group maturity $\left(=\frac{\text{number of matured organisms}}{\text{number of total organisms}}\right)$ in less 70 mm. length group is 0, and that it becomes increasing with the length group becomes larger.In 80-95 mm. length group, 50 per cent of them is matured. According to the data from Wakasa Bay shown in figure 26, gonad weight of 80-99 mm. length group in May is 0.25 gr. level in the maximum. Compared this with the same length group of October and November, the former is larger than the latter which can not be measured and compared with gonad weight of length group more than 100 mm., it shows very low value. Thus length group more than 100 mm. should be considered a chief spawner.

Figure 27 is the geographical representation of the percentage of body length composition measured in all water regions, arranged all Data from Survey of "Iwashi"



Fig. 27 Body-length composition of anchovy, by month and area (Total during the period 1951～1954, except Hokkaido for only 1953).

i) Arabic numerals in each graph denote the number of anchovy measured, but in Hokkaido it is indistinct.
ii) No anchovy was caught in Mutsu Bay during the period February-May and around Hokkaido during the period January-May.

Ordinate—length composition. Abscissa—body length in cm..

Rersources (Ser. B, 1951-1954), — as to Honshu, the percentage shows the value obtained by body length frequency for all materials that were purposively sampled every month ; on the other hand, as to Hokkaido (Funka Wan and the Tsugaru Strait), it shows the value which were estimated as the body length comosition of the total catch expressed in number of individuals for each month, on the basis of the composition of samples that systematically obtained by "multiple stage sampling method"

Putting these knowledges of the monthly distribution of eggs, of seasonal variation of mautrity of gonads and of biological minimun together, a part of oblique line in figure 27 is just for main spawning group.

There are many reports about growth of anchovy young (Yokota, 1953 ; and the like). About monthly growth of it in the Japan Sea region, Watanabe (1955) estimated that it grows 30 mm. in a month after hatched, 5.6 cm. in three months and 7.5 cm. in five months. Applied mechanically these estimations to the occurrence season of larvae no more than 75 mm. body length group shown as a black part in figure 27, its preceding spawning season is attended with table 8.

Table 8 Occurrence of anchovy-young and its preceding spawning seasons in various regions.

Region	Period of young occurrence	Spawning season
Yamaguchi Pref.	April – August	January – April
Wakasa Bay	July October – November	February – April May – July
Toyama Bay	August – September December – January	April – June July – October
Mutsu Bay	July – December	June – August
Hokkaido *	August – October	May – August

* Hokkaido depends mainly upon the data from the Tsugaru Strait and Funka Bay.

Comparing the estimated spawning season as above mentoined with that confirmed by eggs distribution, the former is a little early in its beginning period. It is estimated that this discord of beginning period of spawning season is due to two factors as follows.

a) Up to now, for tracing growth of anchovy, variation of body length composition in the same region has been used chiefly. But, in the foundation of this method, there must be a premise that, in its water region, there is no addition of anchovy from any other waters, that is, the measured anchovy are all spawned, hatch and grow in the same region alone. In spite of that, this premise has not been proved at all. Rather, according to the way of the Tsushima Current, it is not unreasonable to think that the larvae come into bay, for instance into Wakasa Bay, riding on the flow of the Tsushima Current, from south-west of the Japan Sea where spawning season set in early and that some eggs and larvae which found abundantly in offshore branch of the Tsushima Current (Shimomura, 1957) are at least naturally following into the same

course. If like this, larvae come into Wakasa Bay from south and north of offshore region, their life circumstances are different from those which are originally growing in Wakasa Bay. Therefore these groups' body length compositions are different each other. Consequently, the spawning season attained by reverse operation from body length composition, premising that anchovys are all spawned, hatch and grow in the region as shown in table 8, discords with the beginning of spawning observed from the captured egg samples. If after hatched a month growth is 24 mm. (Aikawa, 1954), time lag between these two is more noticeable.

b) Another reason is hitherto presumed growth of early larval stage would be less than real growth.

These two reasons mentioned above are considered. If, in the case of anchovy which spawning period is longer (not always the same organisms), there found first condition above stated, it is necessary still methodlogical examination to presume growth of youngs, by the way of following the body length composition of youngs which occur in definit water region.

6. Summary

1) It has already been about four years since General Survey on the warm Tsushima Current was commenced in April 1953, moreover 3,000 times towings were made, knowledge of seasonal and geographical distribution of anchovy's eggs and larvae increased rapidly. This paper completes the "survey" in outline centering 1954.

2) The spawning season throughout the whole Japan Sea extends a whole year, warm season from April to October is main season, especially June is the best time and in October there is a climax but low.

Occurrence of larvae is somewhat later than that of eggs and the season is July.

3) The north end of egg distribution is in April, in Wakasa Bay and it goes north swiftly to Gongen Saki of Aomori Pref. with the mighty northing of the Tsushima Current in May, going to north, Ishikari Bay in June and it spreads to the Okhotsk Sea through the Soya Strait in July. While, like eggs, larvae can be seen from June on in the offing of the Japan Sea. The distribution of eggs and larvae of August is resemblance of that of July, but, in September, the north end of egg-occurrence is found around Sado Island, going south, and October is the same. Eggs and larvae can be little observed from November to December (but the authors do not expect that the northing and the southing of above-mentioned distribution region are caused by anchovy belonging to the same race).

The main spawning grounds are following three regions.

Wakasa Bay
Toyama Bay
Ishikari Bay

4) The minimum water temperature of eggs and larvae occurrence is 10°C. and 13°C., respectively. According to another data, the authors conclude the lower limit for anchovy's efficient reproduotion is 13°C.. The upper limits for it can not be seen in the Japan Sea. Then, the optimum temperature for growth of larvae and for spawning can be concluded to range from 17° to 24°C..

Both eggs and larvae of anchovy occur in the range from 15 Cl ‰ to 19 Cl ‰.

5) On the occurrence conditions of eggs and larvae by time, there found not enough conclusion in consequence of imperfectness in collecting method.

6) Present method to estimate the anchovy's growth at larval stages by the seasonal variation of body length composition in some regions does not well coincide with the geographical distribution and the seasonal change of adult's maturing period. Therefore, this paper deals with the discussion for the existing research method.

7. Literature

1. Aikawa, H. (1954). *Katakuchi-iwashi no shigen seibutsu gaku teki kenkyu* (Fisheries biological studies on anchovy). Mimeographed.
2. Japan Sea Reg. Fish. Res. Lab. (1951, 1952, 1953, 1954). Data from survey of "iwashi" resources in Japan Sea-Ser. B. In Japanese.
3. Kawamura, H. (1955). *Higashi-tsushima-suido ni okeru chigyo no kisetu-teki shutsu-gen keiko* (Seasonal tendency in occurrence of larval fishes in the Higashi-suido of the Tsushima Strait). *Collected These of the 2nd Symposium on GSTC**. Fish. Agency.
4. Matsubara, K. (1955). Fish morphology and hiearchy 1-3. Ist ed., Tokyo Ishizaki Shoten. In Japanese.
5. Ministry of Agriculture and Forestry. (1951, 1952, 1953, 1954, 1955). *Annual report of catch statics on fishery.* In Japanese.
6. Nakai, Z. and others. (1955). Progress report of the co-operative "iwashi" resources investigations, April 1949-December 1951. Tokai Reg. Fish. Res. Lab. In English.
7. Shimomura, T. (1957). Geographical distribution of larval fishes, Decapoda, Arthropoda, and various eggs in the Japan Sea, in August, 1955. *Bull. Japan Sea Reg. Fish. Res. Lab.* 6. In English.
8. Tokai Reg. Fish. Res. Lab. (1951, 1952, 1953, 954). Data from survey of "iwashi" resources in the Pacific area off Honshu-Ser. B. In Japanese.

For publications with no English title, the Japanese title is given in italics and the translation thereof in parentheses.

* Hereinafter GSTC denotes the abbreviation for "General Survey on the Warm Tsushima Current".

9. Uchida, K. (1956). On the occurrence of larval fishes and eggs in the Tsushima Current regions (Lecture delivered at the 5th Symposium on GSTC).

10. Watanabe, K. (1955). Some notes on the variation in the number of vertebrae of Japanese anchovy, *Engraulis japonicus* and the monthly growth in its juveniles. *Ann. Rep. Japan Sea Reg. Fish. Res. Lab.* **2**. In Japanese.

11. Yokota, T. (1953). Studies on the sardines in Hyuga-Nada and Bungo-Strait. Rep. *Nankai Reg. Fish. Res. Lab.* **2**. In Japanese.

Chapter II "Saba" (Mackerel, genus *Scomber*)

1. Preface

Mackerel, including "hon-saba" *Scomber japonicus* Houttuyn and "goma-saba" *Scomber tapeinocephalus* Bleeker, is one of the main components in the coastal fisheries-catch in the surrounding waters of Japan. It has been an important subject for study in General Survey on the warm Tsushima Current to make an ecological study on mackerel and a mechanism in variations of the fishing conditions. The authors here deal with the spawning of mackerel, on the basis of the maturings in adult mackerels and of the geographical distribution of its larvae.

2 Maturing of adult mackerel

1) Morphometric samples

Since General Survey on the warm Tsushima Current was commenced in April 1953, the morphometric measurements of mackerel catch, including that of gonad weight, have been carried out at various places in all seasons. This chapter is based upon the data that the eight Prefectural Fisheries Experimental Stations along the Japan Sea coast of Honshu—Shimane, Tottori, Kyoto, Fukui, Ishikawa, Niigata, Akita, and Aomori—measured and reported.

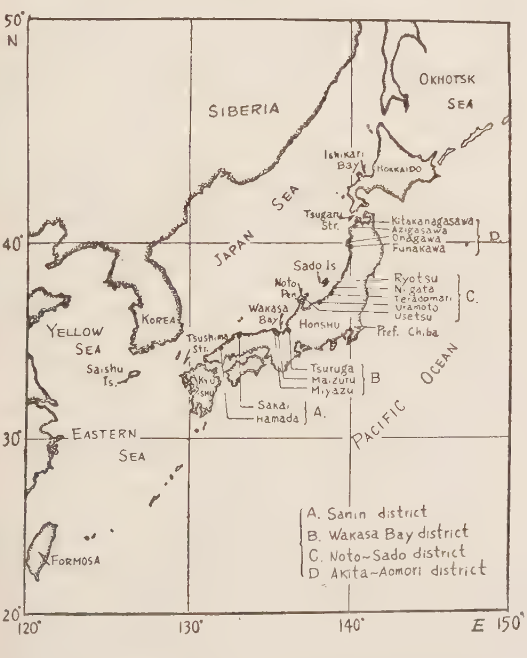


Fig. 1 Locations of fishing ports(•), at which morphometric measurments were made.

The positions of the fishing ports where the measurements were conducted are given in figure 1. Number of total measured organisms amounts to 4,780, comprising 687 in 1953, 1,553 in 1954 and 2,540 in 1955.

2) Sex ratio of "hon-saba"

Scomber japonicus Houttuyn

Kashara & Ito (1953) obtained a value $\frac{♀}{♀+♂}=0.53$, arranging the data of total 5,062 mackerels measured at various places along the coast of the Japan Sea and of the Yellow Sea during the period from 1930 to 1950; these data were only dealt with larger mackerels than 290mm. in body length. Steven (1952), by the same method, obtained a value $\frac{♀}{♀+♂}=0.52$ on *Scomber scombrus* Linnaeus.

The occurrence frequency of female, male and of organisms which sex could not

be distinguished, dividing the data (4,780) treated by the authors into body length classes which sectioned at 50 mm. intervals, is given in table 1.

Table 1 Sex ratio $\left(\frac{♀}{♀+♂}\right)$ of the mackerels captured at various places along the west coast of Honshu.

Year / Item / Body Length (mm.)	1953～1955						1953					
	T*	♀	♂	?	?/T	♀/(♀+♂)	T*	♀	♂	?	?/T	♀/(♀+♂)
Total	4,780	2,360	1,738	682	0.14	0.58	687	394	226	67	0.10	0.64
100～149	3	0	1	2	0.67	0						
150～199	104	3	0	101	0.97	1.00						
200～249	539	130	102	307	0.57	0.56	32	5	2	25	0.78	0.71
250～299	944	420	356	168	0.18	0.54	84	40	21	23	0.28	0.66
300～349	1,110	571	469	70	0.06	0.55	79	35	32	12	0.15	0.52
350～399	1,595	913	650	32	0.02	0.58	391	243	141	7	0.02	0.63
400～449	477	318	157	2	0.00	0.67	98	69	29	0	0	0.70
450～499	8	5	3	0	0	0.62	3	2	1	0	0	0.67

Year / Item / Body length (mm.)	1954						1955					
	T*	♀	♂	?	?/T	♀/(♀+♂)	T*	♀	♂	?	?/T	♀/(♀+♂)
Total	1,553	834	630	89	0.06	0.57	2,540	1,132	882	526	0.21	0.56
100～149							3	0	1	2	0.67	0
150～199	2	1	0	1	0.50	1.00	102	2	0	100	0.98	1.00
200～249	61	24	16	21	0.24	0.60	446	101	84	261	0.59	0.55
250～299	426	213	179	34	0.08	0.54	434	167	156	111	0.26	0.52
300～349	415	208	185	22	0.05	0.53	616	328	252	36	0.06	0.57
350～399	471	270	190	11	0.02	0.59	733	400	319	14	0.02	0.56
400～449	175	117	58	0	0	0.67	204	132	70	2	0.01	0.65
450～499	3	1	2	0	0	0.33	2	2	0	0		1.00

*T=Number of examined fishes.

The occurrence frequency of organisms which sex could not be distinguished is on the whole 14 %, and the frequency is inclined to become larger in smaller body length class; for instance, seeing the year 1955 when the largest number of mackerels was measured, the sex determination in the majority (98%) of body length class 150 mm.～199 mm. can not be made; in the body length class 200 mm.～249 mm. it falls down to 59%……, and in larger body length class more than 300mm., the sex determination is able to be made on almost whole mackerels. Tanoue (1955) reported that, on the basis of breeding and observing of "goma-saba", *Scomber tapeinocephalus* Bleeker, the sex determination by means of gonad becomes able when body length reaches 227±10.3mm. This coincides nearly with the case of the above mentioned

"hon-saba", *Scomber japonicus* Houttuyn.

Number of "hon-saba" which sex determination was possible take up 86% in the total number. On the whole, number of females is larger than that of males every year and also in each body length class of each year. Owing to the imperfection of the present sampling method and the like, it is unable to show quantitatively the sex ratio of "hon-saba"; but it is estimated that the ratio ♀ : ♂ is not 1 but slightly over 1.

3) Maturing period of "hon-saba" and characteristics in composition of spawning "hon-saba" in the Japan Sea

Yoshida (1954), Enami & Aikawa (1955), Kittaka & Funada (1955), Kurita (1955), Okachi (1955), Dohi (1955), Noguchi & Bito (1955), Noguchi & Kojima (1955), Enami & Aikawa (1956) and other studied the spawning, on the basis of the maturing of "hon-saba" caught on the Japan Sea side of Honshu. From these studies the following points have been made clear.

i) The spawing season on the Japan Sea side of Honshu is generally the period from May to August.

ii) The spawning season begins earlier in the southern region than in the northern; it extends from May to June in the coastal region of Tottori Pref., from May to July in the coastal region of Hyogo Pref., from May to June in Wakasa Bay and from June to August in Niigata Pref..

iii) In the waters west of Wakasa Bay the spawn is laid mainly by 2-age group and in the waters north of Noto Peninsula mainly by 3-age or 4-age group and more.

Enami & Aikawa (1956), making a detailed study of the ovarian maturing, demonstrated the maturing process as follows.

i) "Hon-saba" which ovary weight does not increase more than 10 gr. in the year round are all immatured and are found abundantly in 0 - age group.

ii) Even if it grew over 10 gr., "hon-saba" which ovary weight is no more than 30 gr. is only an unsubstantial female; this is mainly found in 1-age group.

iii) "Hon-saba" with ovary weight more than 30 gr. all spawn in their spawning season; this is mainly 2 - age group and more.

The multiple spawning of "hon-saba" has been proved by the poly-mode in the frequency distribution of ovarian eggs' diameters (Enami & Aikawa, 1955; 1956 and others), and by the histological studies on gonad (Tateishi, 1956). This forms a condition that makes it difficult to estimate the spawning season through only the seasonal variation of ovary weight or gonad weight.

Table 2 shows the monthly variations of the gonad weight frequencies in each body length class and in each of four regions given in figure 1. As it is probably

unable to study the yearly changes of maturing, owing to the imperfectness in samplings, the monthly variations are here given collectively; and also as there found no large difference between the seasonal variation of seminal gland weight and of ovary weight, though seminal gland weight show a tendency to become a little larger than ovary weight, now only the total of these two is shown.

The body length (age) composition of "hon-saba" catch on the Japan Sea side of Honshu varies with the north and the south (table 2). Table 3 shows number of

Table 3 Nnumbeo of measured mackerels with gonad more than 30 gr. weight, on the Japan Sea side of Honshu.

District / Fork length	San'in		Wakasa Bay		Noto～Sado		Akita, Aomori	
mm.		%		%		%		%
Total	167	(100)	414	(100)	183	(100)	152	(100)
150～199	0	(—)	0	(—)	0	(—)	0	(—)
200～249	0	(—)	0	(—)	0	(—)	0	(—)
250～299	3	(2)	1	(0)	0	(—)	1	(1)
300～349	111	(66)	73	(18)	51	(28)	5	(3)
350～399	42	(25)	254	(61)	90	(49)	66	(43)
400～449	11	(7)	86	(21)	42	(23)	80	(53)

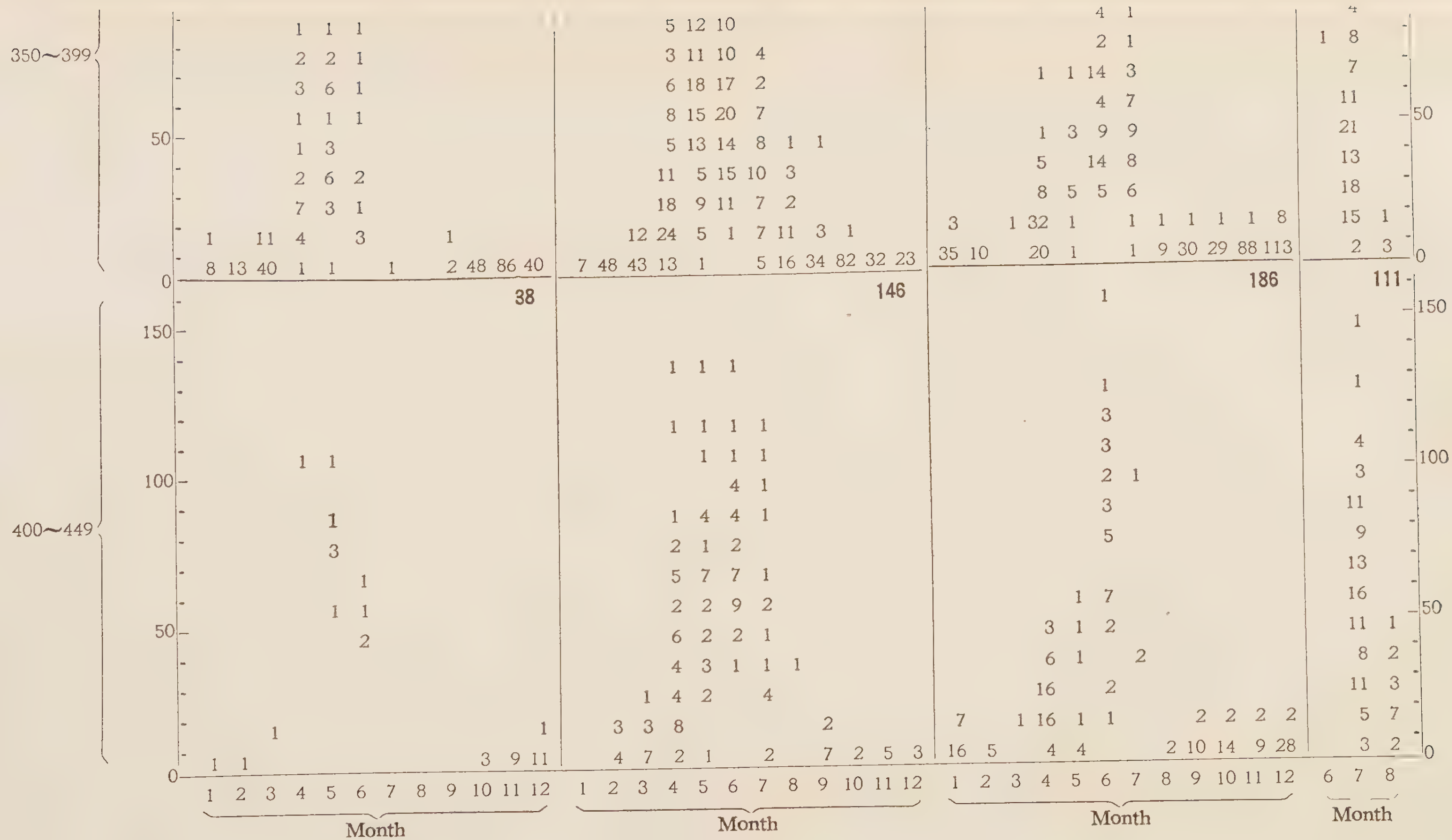
"hon-saba" which gonad weights are all over 30 gr.. Especially in order to study the composition of the spawning adults, here the level 30 gr., that Enami & Aikawa (1956) pointed out as cited above, is used. Seen table 3 the bulk of spawnable "hon-saba" is that more than 300 mm. in body length (namely, according to the relation between age and growth (Yonemori & Aikawa, 1956), on the whole the spawn is laid by organisms more than two years old). On the other hand, the body length composition of the spawning adults varies remarkably with the south and the north on the Japan Sea side of Honshu—in San'in district, "hon-saba" with 300～349 mm. in body length account for two thirds of the spawning adults, and organisms over 400 mm. are very few, while, in the coastal waters from Akita Pref. to Aomori Pref., "hon-saba" with 400～449 mm. hold the greater part of the spawning adults and there found no small spawning adults like in San'in district. Wakasa Bay and the waters from Noto Peninsula to Sado Is. are converting region between the above two regions.

Seeing the frequency distribution of gonad weights of April in the southern waters, San'in district and Wakasa Bay district, it is likely to be that, in the same district, the elder group matures sexually a little earlier than the younger, and that in the same body length class, group in the southern region does so than that in the northern region (table 2). The abundance of the elder organisms in the northern region and the earlier maturing in the elder organisms seem to moderate a tendency that the spawning season of "hon-saba" overdue with going north.

The spawning season of each district estimated from table 2 coincide almost with

Table 2 The seasonal variations in frequencies of mackerel gonad weights, by size and area.

Fork length (mm.)	Gonad Weight (gr.)	San'in district Month												Wakasa Bay district Month												Noto~Sado district Month												Aomori~Akita district Month			Gonad weight (gr.)
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	6	7	8	
150~199	10												**5***												**8**												**90**			**1**	10
	0				1			1	2	1							7					1						23	10	55	1		1						1		0
200~249	30												**217**												**71**												**249**			**1**	30
																																1									
						3	1																									1									
	0			25	19	42	1	2	9	23	3	89				3	13	11				40	4					32	45	120	5	8		1	18	18		1			0
250~299	40												**680**												**122**												**129**			**19**	40
						2	1												1																				1		
					1	9	2	1											1											1		1							1		
					3	51	31	6	3								2	5	10	1										2	1	3							4		
	0			46	68	98	88	141	49	4	7	69				5	3	28	24	9		8	25				5	4	1	15	14	14	30	14	9	5	10		13		0
300~349	90												**471**												**344**												**273**			**21**	90
																		1	1																						
							1											1	1											1											
						3	4											3	2	1											1										
					1	7	15										1	3	11											1	3	1									
	50				3	8	20											8	11	3											10	10							1		50
					7	29	11	2										8	13	5										2	13	9							4		
					16	30	24										1	11	14	1									1	5	14	15							4		
				1	10	14	28	4	1		4						3	9	8	12	3								4	12	6	18							10		
	0		6	84	22	6	11	25	15	9	35	15		13	3	61	10	2	1	5	3	49	25	23	14		16		7	17	4	5	26	22	7	26	17		1	1	0
	150												**313**												**670**												**500**			**106**	150
																				1																					
																		1	2																						
					1	2												1	2																						
																		1	4												1										
	100				1	3												1	7	1										1	1								1		100



* Gothic numerals denote the total number of morphometrically measured mackerels.

the past results; namely, in San'in district, "hon-saba" with gonad weight more than 30 gr. appears in the period from April to July, and the spawning season of the elder group seems to range from April to May, and that of the younger group from May to June; in Wakasa Bay, "hon-saba" with gonad weight more than 30 gr. appears during the period from April to August, and the elder group seems to lay the spawn in the period from April to July, the younger during May~July; in the waters from Noto Peninsula to Sado Is., "hon-saba" with gonad weight more than 30 gr. appears in the period from April to July, the best spawning season seems to be June and July; in the coastal region from Akita Pref. to Aomori Pref., the morphometric measurement has been carried out only during the period from June to August, in consequence of the fact that the fishing season or the migration season of "hon-saba" is found only from June on (fig. 2), and in this region the best spawning season seems to be July.

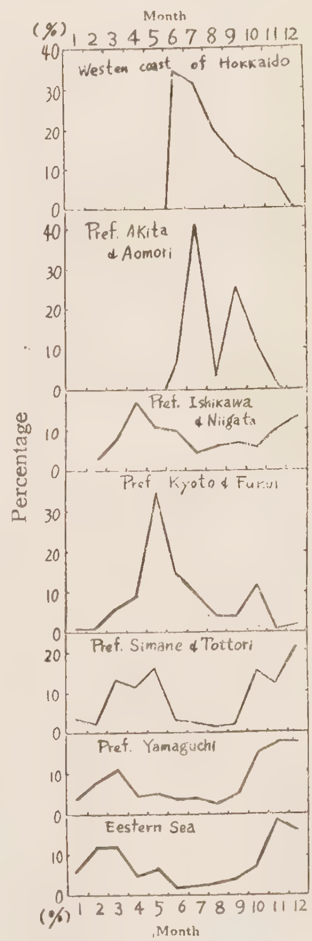


Fig. 2 The ratio of the monthly catch of mackerel to the annual total, by area.

4) Maturing of mackerel in the waters adjacent to the Japan Sea.

A) The East China Sea and the west coast of Kyushu

In these regions "hon-saba", *Scomber japonicus* Houttuyn, get mingled with "goma-saba", *Scomber tapeinocephalus* Bleeker, as mentioned after. The spawning of "saba" (mackerel), including "hon-saba" and "goma-saba", has been left unknown up to the recent years, while since General Survey on the warm Tsushima Current was commenced, its knowledge is going in details swiftly.

Yabe (1953), Murakami (1954), Kokubu (1954), Tanoue & Enami (1954), Tsujita (1954), Kokubu & Takahashi (1954), Tanoue (1955) and others presumed the spawning season and the spawning ground, on the basis of the states of the maturing of the spawnable adults. To sum up these reports, the spawning ground in these two regions extends probably over the waters from the offing north-east of Formosa to the eastern side of Saishu-to Is. (Cheju Do Is.), Korea, and the spawning season ranges from about the latter part of January to that of June or at latest to about the first part of July; and it is assumed that the

spawning, early in the season, will begins at first in the southern waters, then, in the latter part of the season, it will spreads out in the northern waters.

In these regions, "hon-saba" also lay the spawn, the spawning ground probably reaches the waters north of lat. 29°～30° N and east of long. 125°～127° E, and the spawning season seems to extend March through June (Kokubu, 1954; Tanoue & Enami, 1954).

B) **The Tsushima Strait region**

As mentioned after, the majority of "saba", gen. *Scomber*, in this region is "hon-saba" *Scomber japonicus* Houttuyn. According to Tokunaga (1954) and Ito (1954), the gonad weight of "saba" increases considerably during from April to June, the spawning season seems to be the period from the first part of May to that of July. Enami & Aikawa (1955) suggested that, judging from the variations in the frequency distribution of the ovarian eggs' diameters, the best spawning season of "hon-saba" in these regions should be May.

C) **The Japan Sea side of Hokkaido**

According to the observation results in the fishing ground of Ishikari Bay (Hokkaido Reg. Fish. Res. Lab., 1955; 1956), during the period from mid-June to mid-July, largest body length class with mode 345 mm. ～425 mm. which is about equivalent to that found in the coastal waters from Akita Pref. to Aomori Pref., visits the bay, and gonad weights are equivalent to those in the coastal region from Akita Pref. to Aomori Pref. or slightly heavier.

3 Identification of mackerel larvae

Genus *Scomber* found in the surrounding waters of Japan contains two species- "hon-saba", *S. japonicus* Houttuyn and, "goma-saba", *S. tapeinocephalus* Bleeker. Each of these species has been identified to this day on the basis of the presence of black spots on the body, the body shape, the number of fin spines of the first dorsal fin, and that of scales in a longitudinal series and the like (Matsubara, 1955), while as there found intermediate forms between the above two species, some biologists attempt to do not make a distinction between "hon-saba" and "goma-saba" but regard as two sub-species or two forms of the single species.

The studies on the morphological differences between the two species has been continued today. Tamura & Ko (1955), Hiyama, Nose & Takaki (1956), and Takeshita & Aikawa (1956), they all found the existence of lags in modes and of statistically significant differences, in several characteristics, compared the segmental and non-segmental characters of "hon-saba" with those of "goma-saba", each of those two species being identified, with the naked eye, by the external shape. Moreover, Murakami & Hayano (1956) found, for the first time, studying the number of interneural spines of scombers in all parts of Japan, that this is the very character to distinguish most plainly "hon-saba" from "goma-saba".

There found clear ecological difference between these two species; "goma-saba" appears in the warmer waters than "hon-saba". The following points, on the distribution of these two species, have been made clear.

i) "Hon-saba" distributes widely throughout the whole area around Japan Archipelago from the East China Sea to Hokkaido, while "goma-saba" mainly in the Pacific region from the East China Sea and the west coast of Kyushu to the offshore region of Chiba Pref.. Therefore, the distribution waters of these two species overlap each other in the East China Sea, on the west coast of Kyushu, and the southern Pacific coast of Japan.

ii) In the East China Sea and on the west coast of Kyushu, "goma-saba" account for 50~80% of annual catch of mackerel, while in the eastern region of Tsushima Is., "hon-saba" holds more than 90%. The north end of "goma-saba" occurrence in the Jappan Sea is probably Shimane Pref..

iii) The larger body group of "hon-saba" advance south to the East China Sea only in the period from winter to spring, no or almost no being found during summer~autumn in the same region owing to perhaps their northing, or migrating toward north. Migration of the smaller and the moderate large body length group of "hon-saba" differs from this (Kasahara & Ito, 1953; Ito, 1954; Kokubu 1954; Murakami, 1954, 1955; Tsujita, 1954).

On the other hand, as stated after, both "hon-saba" and "goma-saba" lay their spawn during from winter to spring in the East China Sea and on the west coast of Kyushu. This period is the time when the larger body group (adult) of "hon-saba" advance south to those waters in large numbers and mingles with "goma-saba". Consequently, there expected a fair chance for the taking of each species' larvae together. But at present it is impossible to definitely identify larvae of these two species. The morphological features of eggs and larvae of "hon-saba" have been observed well (Kamiya, 1916, 1925; Uchida, 1943) but not on them of "goma-saba." Yabe (1953) regarded the fifty two larvae ranging from 3.8 mm. to 7.1 mm. in body length, which he caught in the sea north-east of Formosa on March 3, 1950, though with some uncertainty, presumably as "goma-saba". This is the first description about the "goma-saba" larvae. Imai (1956), compared the mackerel larvae collected in the southern East China Sea and in Satsunan district (Kagoshima Pref.) with those (surely "hon-saba") obtained in the Japan Sea, which sent by the authors, suggested that the former is formed of ones having a close affinity with the latter (1) and ones do not so (2), and that the (2) is probably "goma-saba", though with a little different characters from the above Yabe's description. Nagasaki Pref. Fish. Exp. St. (1955) reported the taking of two larvae with something of "goma-saba", but the position of anus differs remarkably from the same Yabe's description. Like this, there found no reliable, morphological description on the larvae of "goma-saba', it is desired to be confirmed by artificial hatching and the like in future.

Consequently, the authors deal with mackerel summarized these two species. However, it should be noticed that mackerel larvae caught in the East China Sea and on the west coast of Kyushu properly contain "hon-saba" and "goma-saba" together; on the other hand, it should be reasonable that mackerel larvae of the Japan Sea are wholly the larvae of "hon-saba", aside from the southern-most region.

4 Geographical distribution of mackerel larvae

1) Collecting of materials

This report deals with 3,177 of samples in total caught mainly on the Japan Sea side of Honshu during the period from January 1953 to July 1956. The identificatios were made as follows:

Materials collected by Yamaguchi Pref. Fish. Exp. St.	by Takeo Ito
Materals collected by Kyoto Fu. Fish. Exp. St.	by Yoshio Kato
Materials collected by 10 pref. fish. exp. sts. except the above two and by Japan Sea Reg. Fish. Res. Lab.	by the authors
A part of materials collected before June, 1954.	by Keitaro Uchida, Prof. of Kyushu Univ.

In order to study the relation between the Japan Sea and its adjacent waters, 1,940 or data in total collected by each pref. fish. exp. st. of Kyushu in the coastal region of Kyushu and in the East China Sea during May, 1953～June, 1956, and 717 of data in total collected in the surrounding waters of Hokkaido (Hokkaido Reg. Fish. Res. Lab., 1955, 1956) are cited in this report. The number of data in the above three regions make a total of 5,834 (stations), having been obtained total 3,432 larvae ranging from 3 mm. to 49 mm. in total length at 302 stations.

Materials collected by "maru-chi" net contains surely eggs of "hon-saba", but it is difficult to identify definitely eggs of "hon-saba" preserved in formalin solution for a short time after its smpling; therefore the identification of eggs of "hon-saba" has not been made generally, except Hokkaido where the fauna of eggs and larvae is simple.

And mackerel larvae collected by tows of "maru-chi" net at the sea surface is mainly made up of post-larvae, while the pre-larvae are very rare. According to Motoda (1955), mackerel eggs have a tendency to go down from the sea surface as they develop; therefore pre-larvae will be found in a deeper layer and post-larvae at the surface.

But to study more precisely the spawning ground of mackerel, it is desired to research the occurrence and the geographical distribution of eggs or pre-larvae. The pre-larvae also are caught well by vertical haul with "maru-toku" net made of GG No.

54 silk bolting cloth (corresponding to Müller gauze No. 3) from a depth of 50 meters; namely in order to fill up a vacancy in the samples obtained by "maru-chi" net, the larvae of "hon-saba" contained in 3,053 of "maru-toku" net materials in total collected during the period 1954～1955 on the Japan Sea side of Honshu are cited here.

2) **Occurrence seasons and occurrence regions of mackerel larvae in the Japan Sea**

Kamiya (1925), Ito, Yamaguchi & Ito (1951), and Kato (1954) made description on the occurrence of mackerel eggs and larvae in the Japan Sea side of Honshu. According to these reports, in Wakasa Bay eggs apperar in June and larvae during June and July; in the waters from Noto Peninsula to Aomori Pref. eggs and larvae apper in the period from May to July together. According to Kittaka (1955) and Okachi (1955), in Wakasa Bay larvae ranging from 20 mm. to 50 mm. in body length begin to occur late in May; Kittaka suggested that it should be derived from the spawing early in May in the waters south of Wakasa Bay.

Arranging the results of "maru-chi" net materials and of "maru-toku" net materials during from January 1954 to December 1955 on the Japan Sea side of Honshu, the occurrence station by month of mackerel larvae are shown in figures 3～13 ; the occurrence in 1954 is restricted to warm season from April to August and also in 1955.

January～March

As given in table 3, during this period no mackerel larva has been obtained.

April (figs. 3～5)

Larvae begin to appear in this month, in the southern-most part of the Japan Sea side of Honshu.

May (figs. 6,7)

Larvae begin to appear even in Wakasa Bay, its northern-most end reaches around the northern tip of Noto Peninsula.

June (figs. 8,9)

The northern-most end of larvae occurrence reaches the west coast of Aomori Pref., showing the fact that the spawn of mackerel is laid throughout the whole area on the Japan Sea side of Honshu. The year 1955 have a tendency that the northing of spawning ground is likely to be a little later than 1954.

July (figs. 10,11)

Also in this month the spawn is laid throughout the whole area as inJ une. But the distribution of post larvae have a tendency to spread out somewhat more into the offshore region compared with that in the last month.

Geographical distribution of mackerel larvae in the Japan Sea, during 1954～1955. (figs. 3～13)

○ : Stations at which "maru-chi" net was towed.

● : Stations at which "maru-toku" net was hauled.

⊙ : Stations at which the above two nets were used.

▧ : Occurrence region of pre-larvae.

▨ : Occurrence region of post-larvae.

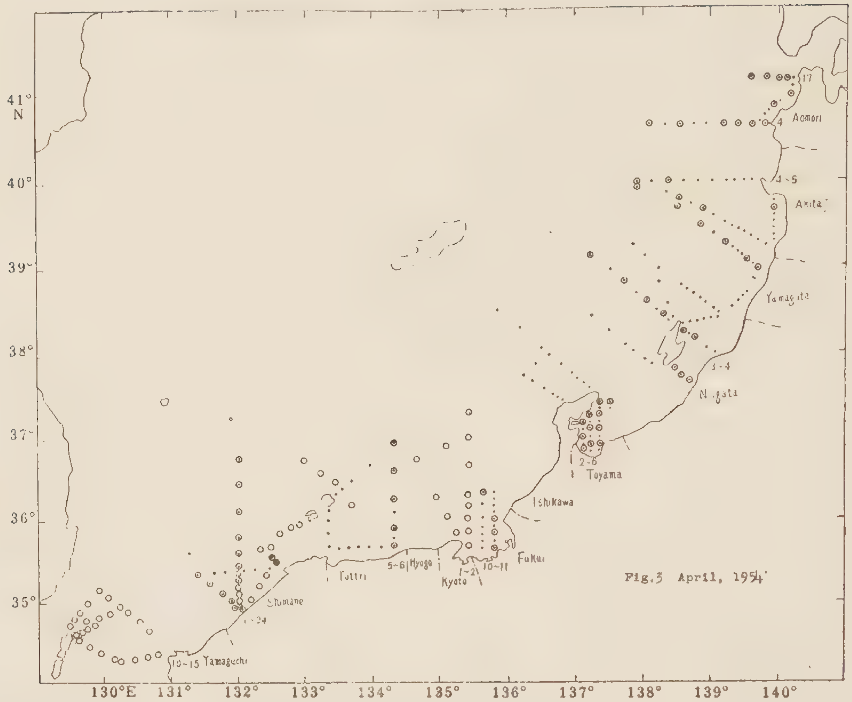


Fig.3 April, 1954

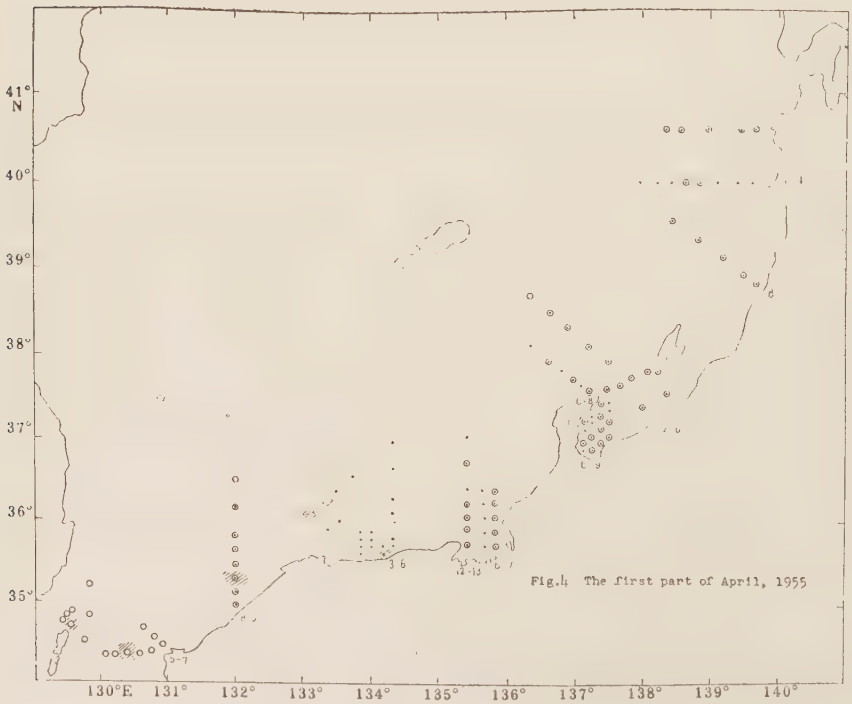


Fig.4 The first part of April, 1955

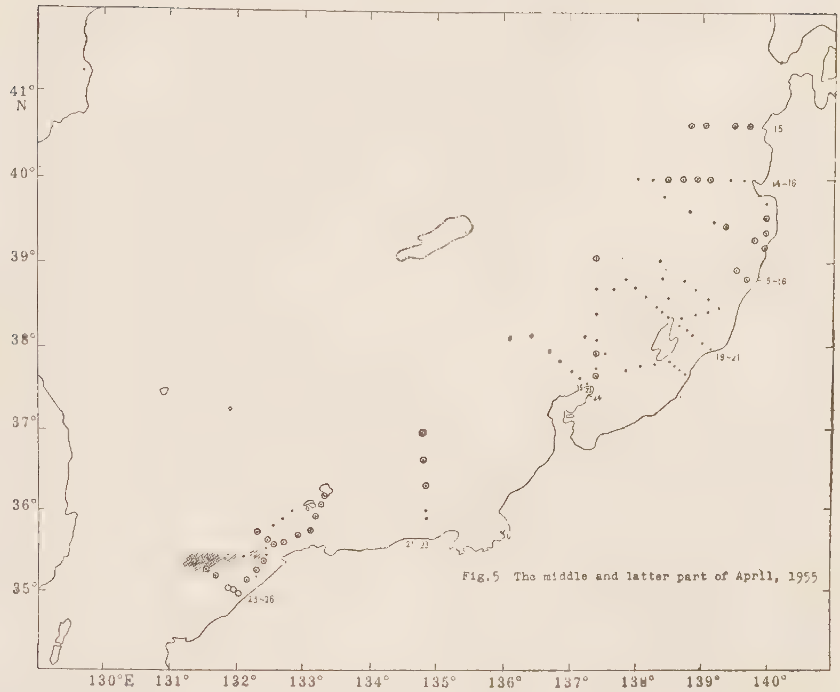


Fig.5 The middle and latter part of April, 1955

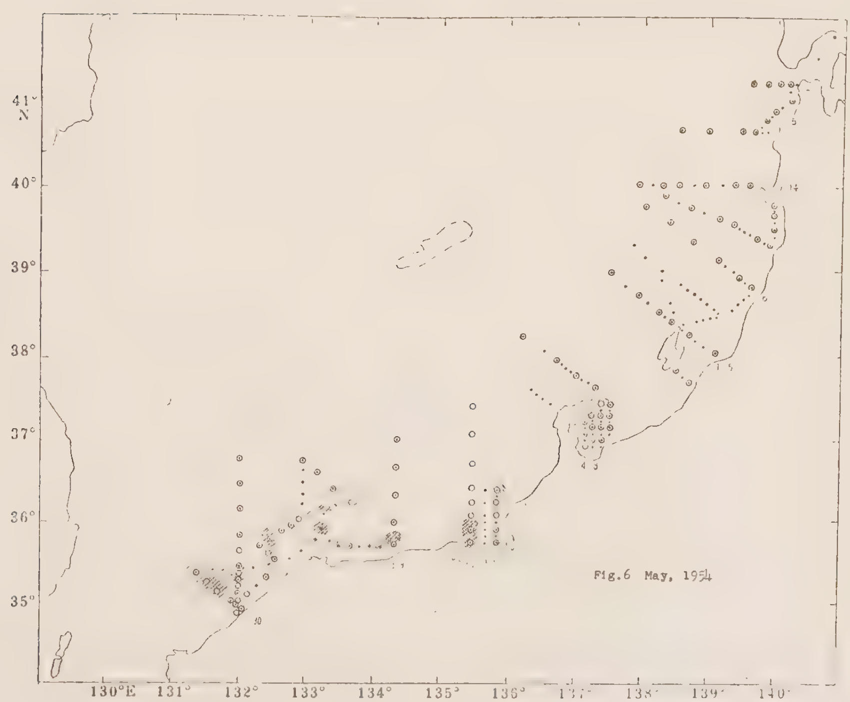


Fig.6 May, 1954

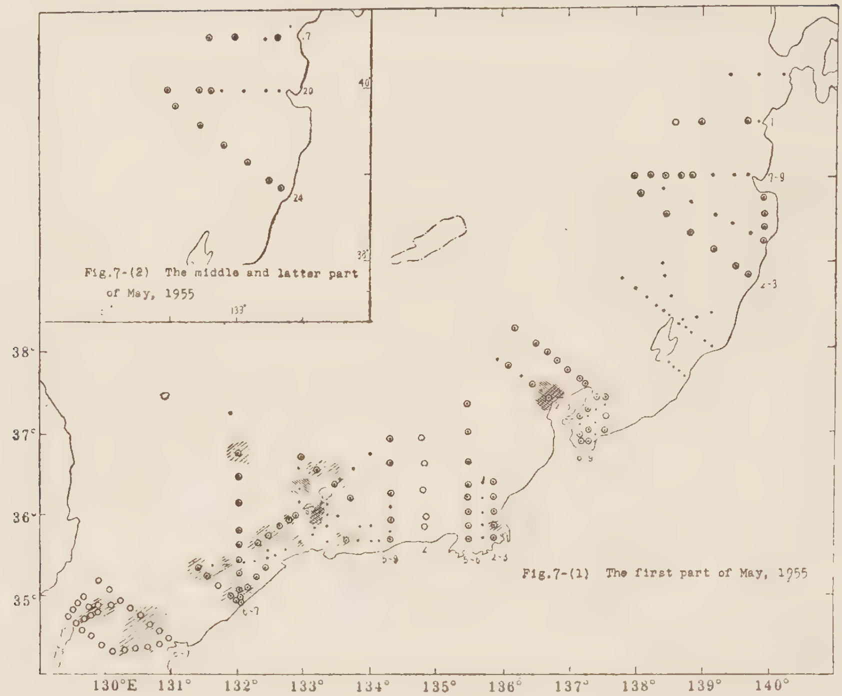


Fig.7-(2) The middle and latter part of May, 1955

Fig.7-(1) The first part of May, 1955

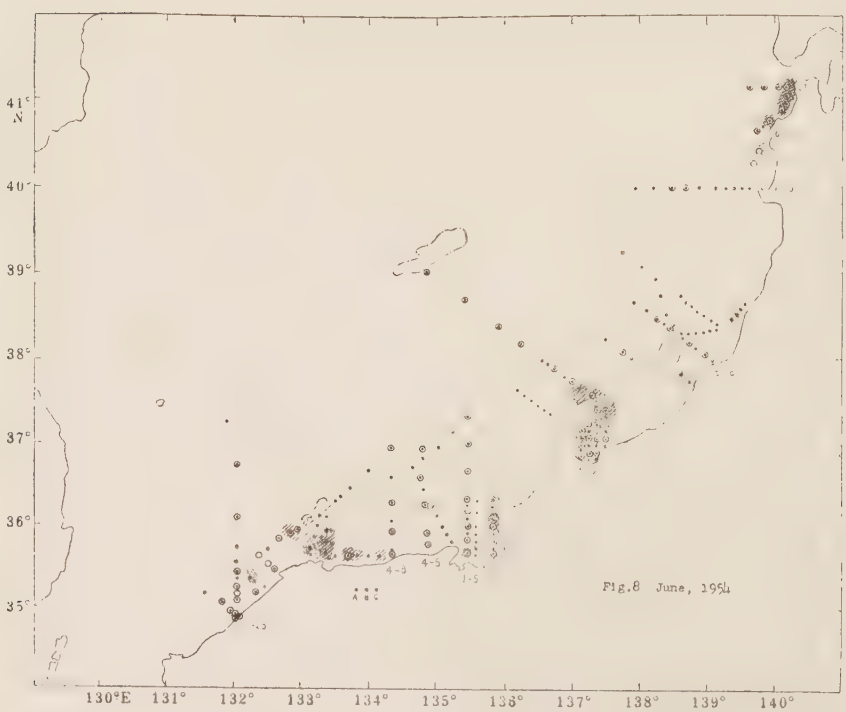


Fig.8 June, 1954

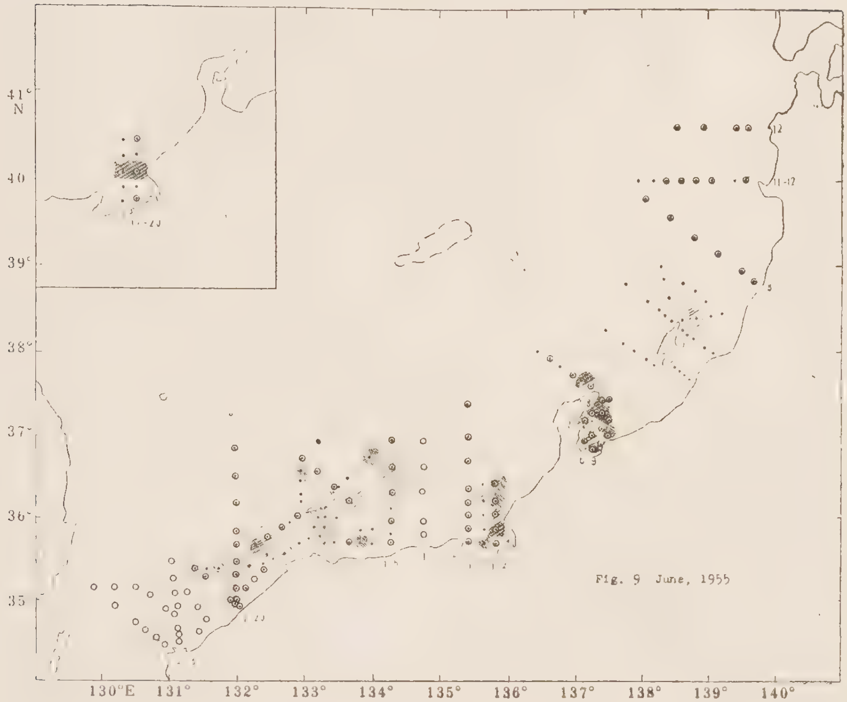


Fig. 9 June, 1955

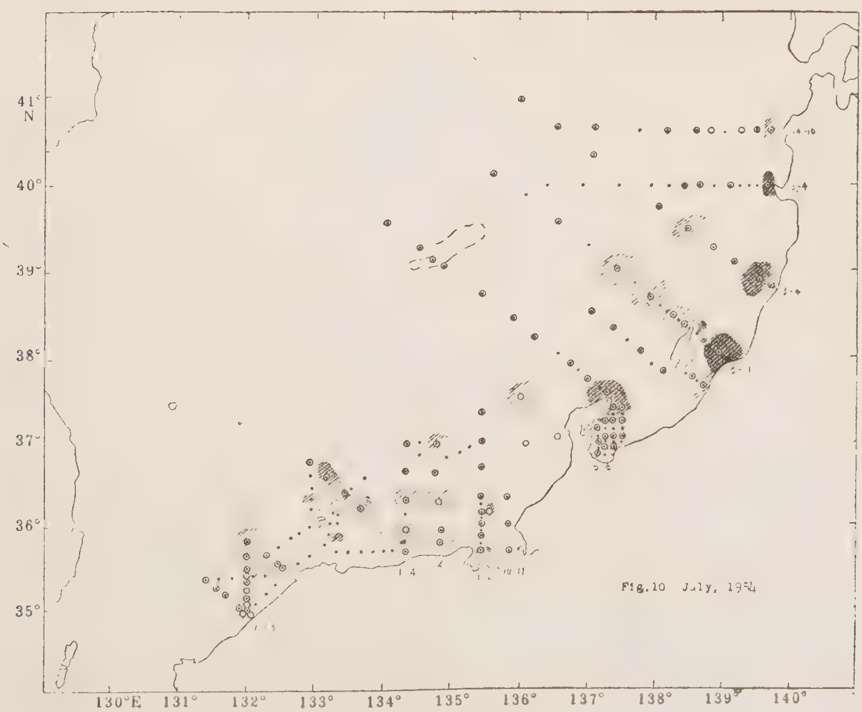


Fig. 10 July, 1954

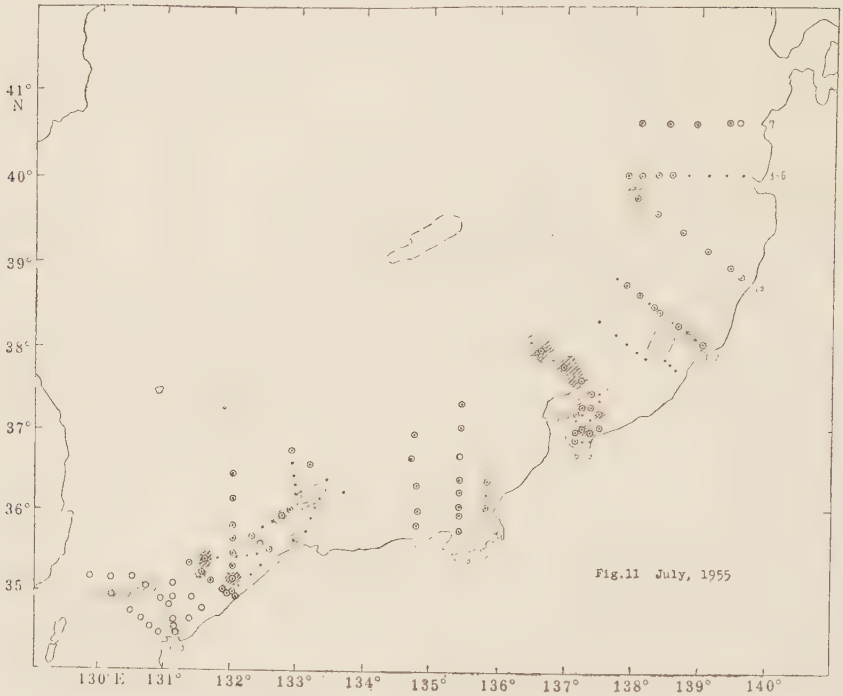


Fig.11 July, 1955

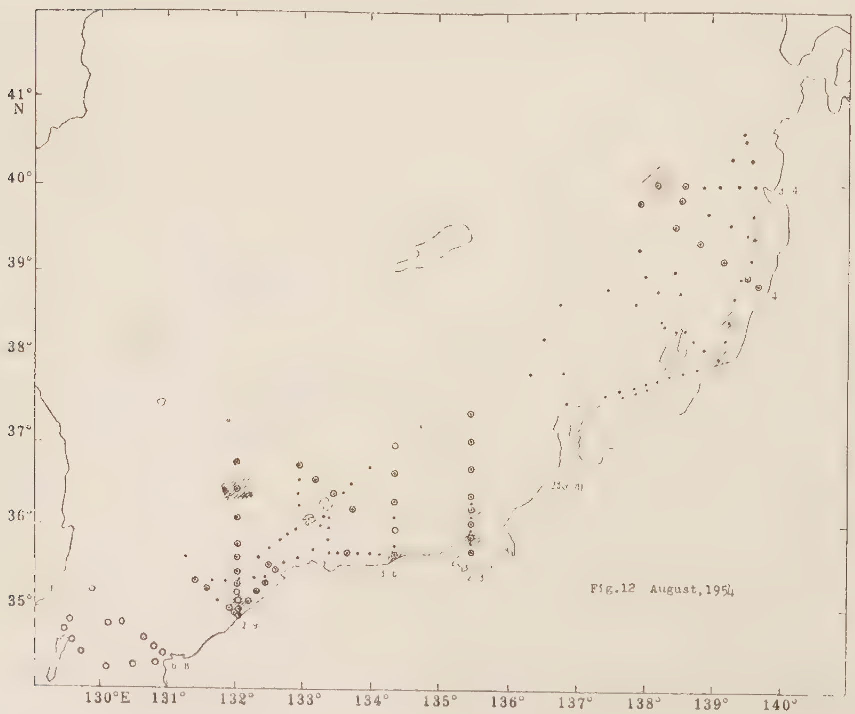
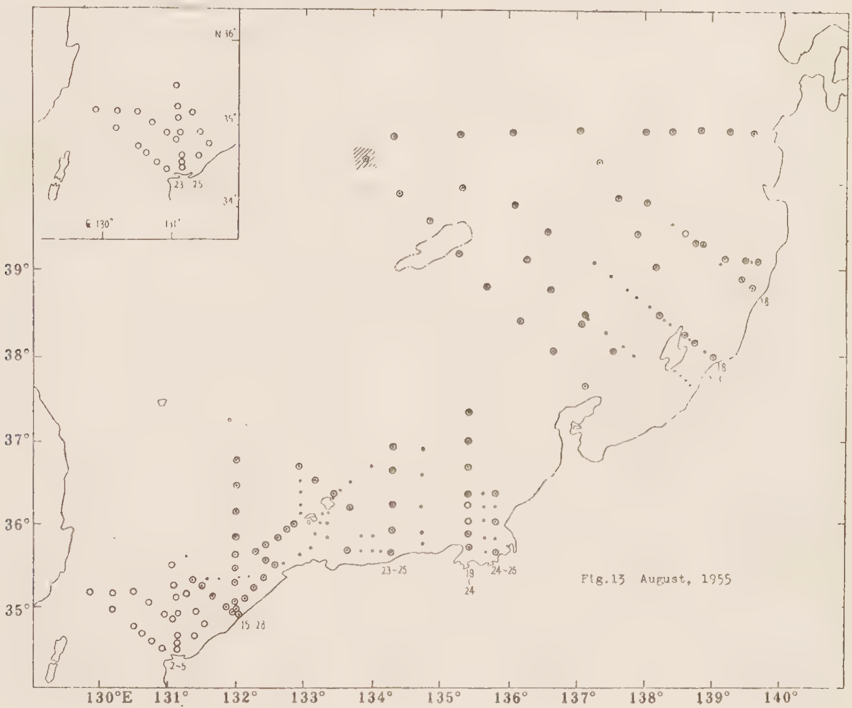


Fig.12 August, 1954

August (figs. 12, 13)

No pre-larvae did occur in 1954 and also in 1955, and post-larvae did not always occur, it is estimated that the spawning had already finished. It is noticeable that single post-larva was collected by the authors at Shunpu Bank placed in the central part of the Japan Sea in August, 1955.



According to these figures, pre-larvae of mackerel have almost wholly been obtained in the continental shelf regions.

3) **Geographical distribution and occurrence period throughout the warm Tshushima Current regions**

Hayano (1954) suggested that, based upon the occurrence states of pre-larvae of mackerel in "maru-toku" net materials, the spawning season and the spawning ground on the west coast of Kyushu should be as follows:

March···the coastal region of Kagoshima Pref.

April ···the waters from Kumamoto Pref. to Goto Is., Nagasaki Pref.

May······more northern region than in April

July······around Tsushima Is.

Kawamura (1955) reported that, on the basis of "maru-chi" net matrials, the occurrence of mackerel larvae in the Higashi Suido of the Tsushima Strait is found in the warm season from April to August, especially from April to June (the largest number is found in May), and that they are very rare during July and August.

Table 4 Monthly occurrence of mackerel larvae.

Region / Item / Month	Around Kyushu				The Japan Sea side of Honshu								Surrounding waters of Hokkaido									
					Wesertn region				Northern region				Japan sea side				Okhotsk side		Pacific side			
	A No. of total sts. at which towings were made	B No. of sts. at which larvae were obtained	C No. of larvae	D Range of total length (mm.)	A	B	C	D	A	B	C	D	A	B	C	D	A	B	A	B	C	D
Total	1,940	71	246	3~49	1,889	116	1,258	3~40	1,288	79	869	3~34	538	32	1,055	3~19	148	0	31	4	4	10~15
January	193	0	0		92	0	0		23	0	0		5	0	0		0	0	0	0	0	
Febrary	130	2	2	7~11	134	0	0		93	0	0		5	0	0		0	0	0	0	0	
March	183	11	31	3~34	137	0	0		146	0	0		2	0	0		0	0	0	0	0	
April	88	6	56	4~13	250	4	17	3~14	213	0	0		26	0	0		0	0	0	0	0	
May	191	24	93	3~49	262	41	792	3~40	200	0	0		46	0	0		0	0	0	0	0	
June	142	17	47	3~12	211	31	235	3~17	167	43	362	3~17	181	0	0		15	0	0	0	0	
July	148	7	9	4~12	177	34	203	3~16	169	34	497	3~16	101	22	1,041	3~16	73	0	0	0	0	
August	160	3	7	5~16	193	6	11	3~10	54	2	10	5~34	104	10	14	7~19	35	0	21	3	3	12~15
September	188	0	0		114	0	0		70	0	0		18	0	0		4	0	10	1	1	10
October	161	1	1	7	139	0	0		60	0	0		36	0	0		21	0	0	0	0	
November	230	0	0		96	0	0		49	0	0		9	0	0		0	0	0	0	0	
December	126	0	0		84	0	0		44	0	0		5	0	0		0	0	0	0	0	
Period that data were obtained.	May, 1953~June, 1956				January, 1953~July, 1956								May, 1953~December, 1955									

There found also many reports that, by the fishing season when larger youngs were caught in small scale fisheries of coastal region, and by its body length composition, estimated the spawning season of mackerel in the East China Sea——namely, on "goma-saba", Tsukahara, Shiokawa & Honda (1955) and Tanoue (1956), and on "hon-saba" Tanoue & Enami (1954). According to these descriptions, mackerel larvae ranging from 40 mm. to 140 mm. begin to visit on to the south and the west coast of Kyushu in March, which are probably derived from the spawn during January～March.

Odate (1955) reported that, around the west and east entrance to the Tsugaru Strait, larvae of "hon-saba" were collected during June and July. Sano & Tamura (1955) and Sano, Tamura & Iizuka (1956) also reported that on the Japan Sea side of Hokkaido, eggs of "hon-saba" appear during June and July, and its larvae in July.

Table 4 summarizes the number of stations, at which net-towings were made, by month and by the sea region, and the occurrence states of mackerel larvae in "maru-chi" net materials (the items are given in the appended table put at the end of this chapter). From table 4, the ratio of the number of stations, at which mackerel larvae were obtained, to the number of total stations, at which horizontal tows of net were made, and the number of mackerel larvae per tow are summarized as drawn in figure 14.

According to table 4 and figure 14, the occurrence period of mackerel larvae in the Tsushima Current regions covers the period from February to September, and the time of beginning plainly comes earlier in the southern waters and later with going north, namely, in the surrounding waters of Kyushu, including the East China Sea, it is February; in the western Japan Sea, April; in the northern Japan Sea, June; around Hokkaido, July. The close, however, is as a whole August without remarkable geographical difference unlike the time of beginning. Consequently, the occurrence period of mackerel larvae is longer in the southern region than in the northern; in other words, the spawning grounds, early in the spawning season, are held prison in the southern regions, spreading out to the north as the water temperature rises.

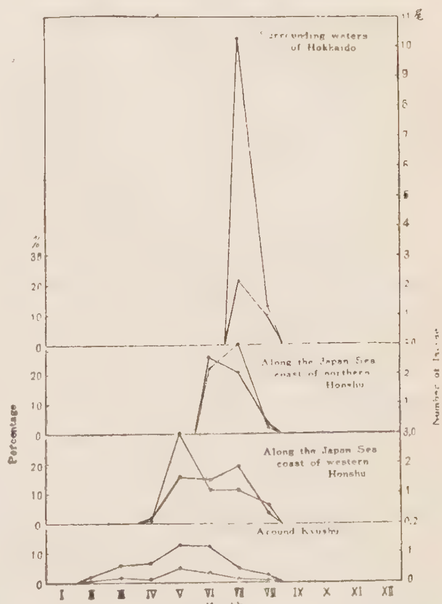


Fig. 14 The ratio of the number of stations, at which larvae were obtained, to the number of stations towed, by month (thick line).
The number of larvae per tow by month (fine line).

Table 5 Monthly occurrence sphere of mackerel larvae, from angles of latitude and longitude.

	The southern end		The northern end		The western end		The eastern end	
	Lat. N.	Long. E.	Lat. N.	Long. E.	Lat. N.	Long. E.	Lat. N.	Long. E.
February	(27°24′) (28°08′)	(125°53′5) (128°55′)	(27°26′) (29°54′)	(123°54′) (129°19′)	(27°26′) (28°08′)	(123°54′) (128°55′)	(27°24′) (29°54′)	(125°53′5) (129°19′)
March	31°46′ (28°48′)	127°23′ (127°24′)	33°10′	128°13	31°46′ (28°48′)	127°23′ (127°24′)	32°47′	129°15′4
April	32°32′4	128°39′	35°35′	134°08′	32°47′1	128°35′	35°35′	134°08′
May	33°10′	128°47′	37°28′	136°28′	32°46′	128°05′3	37°25′	137°22′5
June	31°19′	130°08′3	41°08′5	139°23′	33°40′	128°26′	41°01′7	140°10′3
July	32°24′	127°31′	44°04′	141°29′	32°24′	127°31′	44°04′	141°29′
August	33°08′	128°32′	44°45′8	140°48′4	33°08′	128°32′	41°25′7	141°41′4
September			41°25′7	141°41′4			41°25′7	141°41′4

The parenthese denote the position of organisms presumably identified as "goma-saba"

Table 5, on the basis of the "maru-chi" net's and "maru-toku" net's materials dealt in this study, express the south, the north, the west, and the east limits of occurrence by means of the latitudes and the longitudes. In the period from February to April, morphologically apparent larvae of "goma-saba" occur in the waters enclosed with parallels of lat. 27°N. & 30°N. and circles of long. 123°E. & 129° E..Yabe (1953) reported the taking of apparent larvae of "goma-saba" in the more southern region (lat. 25°53′N, long. 124°35′E). Apart from these examples, the south limits and the west limits of occurrence region of mackerel larvae are, on the whole, every month situated within the zone from lat. 31° N. to 33°N. and long. 127° E. to 128° 30′E., respectively, and they show no remarkable change during from March to August. While the north limits and the east limits move by 12° to 13° toward the north-east both in the parallel and in the circle of longitude during from March to July; namely, as mentioned previously, the occurrence confined to region south of Goto Is., Nagasaki Pref. in March goes north with the advance of months, reaching the north-west off Ishikari Bay, Hokkaido, disappearing all at once in September throughout the entire area.

Figure 14 also shows clearly the fact that the best time of occurrence gets later and shorter in the northern regions, it should be noticed there is trend that, at least in outward appearence, the density of larvae organisms is smaller in the southern regions, and on the contrary larger in the northern. For the sake of conditions in samplings, improper though a quantitative analysis may be, it remains unexplained whether such phenomenon will be derived from the geographical differences in the horizontal and vertical distributions created by the sea conditions or derived from the

quantitative differences in spawning. This is an important matter in studying the relative gravity of spawning ground in each region.

4) **Vertical, diurnal migration of mackerel larvae**

Sette (1943) reported that the larvae of *Scomber scombrus* Linnaeus in the Atlantic seem to swim up near the sea surface at night and go down in the daytime. As for the vertical distribtion and the diurnal migration of mackerel larvae in the Japan Sea, there found no report except that of Sano & Tamura (1955); they reported that in Ishikari Bay, Hokkaido, larvae of "hon-saba" are obtained at the surface abundantly only during the nights.

Table 6 Occurrence of mackerel larvae by time.

Region	Japan Sea side of Honshu									
Period	Western region: April～August					Northern region: June～August				
Item / Time	A No. of total sts., at which towings were made.	B No. of sts., at which larvae were obtained	C No. of larvae	B/A (%)	C/A	A	B	C	B/A (%)	C/A
Total	1,089	116	1,258	10.7	1.2	390	79	869	20.2	2.2
00:00～05:59	139	17	64	12.2	0.5	60	11	275	18.4	4.6
06:00～11:59	367	34	215	9.3	0.6	128	33	375	25.8	2.9
12:00～17:59	417	52	221	12.5	0.5	101	19	178	18.8	1.8
18:00～23:59	146	11	753	7.5	5.2	59	9	27	15.3	0.5
Unknown	20	2	5			42	7	14		

Region	Surrounding waters of Hokkaido									
Period	Japan sea side: July～August					Pacific side: August～September				
Item / Time	A	B	C	B/A (%)	C/A	A	B	C	B/A (%)	C/A
Total	205	32	1,055	15.6	5.1	31	4	4	12.9	0.1
00:00～05:59	42	5	208	11.9	5.0	5	1	1	20.0	0.2
06:00～11:59	57	6	12	10.5	0.2	6	0	0	—	—
12:00～17:59	58	6	30	10.6	0.5	11	2	2	18.2	0.2
18:00～23:59	48	15	805	31.2	16.8	9	1	1	11.1	0.1
Unknown	0	0	0			0	0	0		

Table 6 shows the states of occurrence of mackerel larvae by time. According to table 6, in the western and northern region of the Japan Sea side of Honshu, there seen no trend that occurrence of mackerel larvae changes regularly in response to

night or daytime. But it would be premature to conclude that, on account of this phenomenon, mackerel larvae will not make a regular diurnal migration; for, as stated in Chapter I Anchovy, most of stations, at which net-towings were made by day, are situated in neritic regions, and by night in offshore regions, although the distribution of mackerel larvae is comparatively restricted to the coastal waters; namely, the changes created by time factor seem to be covered by them created by geographical factors. Seeing table 6, number of mackerel larvae ("hon-saba") per tow on the Japan Sea side of Hokkaido is larger during the night than in the daytime. Such a suggestive result would derive itself from the fact that towings of net in the region were made concentrating in Ishikari Bay, one of the most important spawning grounds, by day and by night. To sum up, the vertical, diurnal movement of mackerel larvae should not be so remarkable as larvae of atka-fish and should be more feeble than anchovy larvae.

5) **Relation between the occurrence of mackerel larvae and the sea conditions**

Kasahara & Ito (1953) suggested that the surface water temperature, when "hon-saba" of the Japan Sea lay the spawn, mainly is likely to range between 13.5°C. and 21°C.. Hayano (1954) reported that, in the neritic region of Kyushu, the surface water temperature when pre-larvae of mackerel occur ranges from 15° to 21.5°C.. Sano & Tamura (1955) reported that, on the Japan Sea side of Hokkaido, it when mackerel eggs occur ranges from 12.1° to 24.4°C., and that the dense occurrence is seen within the range 15.5°~19.2°C., and that the eggs at an early stage of development are abundant within the range 17.5°~19.2°C.. Sano. Tamura & Iizuka (1956) also reported that, on the Japan Sea side of Hokkaido, the surface water temperature, when eggs of "hon-saba" occured, ranged from 13° to 16°C. in 1954, and 15° to 25°C. in 1955, differing by year. Enami & Aikawa (1956) found an existence of some relation between the rising of surface water temperature up to 17.8°C. since the lowest period from February to March and the increasing in gonad weight of mackerel, and reported that gonad weight reaches the highest at about 17°C., the wholly matured eggs disappearing over 25°C..

Table 7 shows the states of occurrence of mackerel larvae by surface temperatur range. The temperature range for occurrence and the best range in the western region of the Japan Sea side of Honshu are the same as these in the northern —— 14°~26°C. level and about 21°C., respectively. On the Japan Sea side of Hokkaido, the temperature range of occurrence ranges from 16° to 25°C., being narrower compared with the above two regions, and the best range is about 19°C., being somewhat lower. On the Pacific side of Hokkaido (around the east entrance to the Tsugaru Strait), the tows of net were made only during August and September, the temperature range of occurrence was 14° to 21°C. level. As, among the above four regions, there found no significant difference in the occurrence temperature of mackerel larvae, the ratio of the number of stations by temperature range, at which

Table 7 Occurrence of mackerel larvae by the surface water temperature range.

Region / Item / Surface temprature (°C.)	The Japan Sea side of Houshu: Western region: Jan.~Mar.: A No. of total sts., at which towings were made.	B No. of sts., at which larvae were obtained	April~August: A	B	C No. of larvae	B/A (%)	C/A	Sept.~Dec.: A	B	Northern region: Jan.~May: A	B	June~August: A	B	C	B/A (%)	C/A	Sept.~Dec.: A	B	Surrounding waters of Hokkaido: Japan sea side: Jan.~June: A	B	July~August: A	B	C	B/A (%)	C/A	Sept.~Dec.: A	B	Pacific Side: August~September: A	B	C	B/A (%)	C/A
Total	363	0	1,089	116	1,258	10.7	1.2	411	0	675	0	390	79	869	20.2	2.2	223	0	265	0	205	32	1,055	15.6	5.1	68	0	31	4	4	12.9	0.1
2.0~ 3.9	0	0	0	0	0			0	0	10	0	0	0	0			0	0	0	0	0	0	0			0	0	0	0	0		
4.0~ 5.9	0	0	0	0	0			0	0	14	0	0	0	0			0	0	15	0	0	0	0			0	0	0	0	0		
6.0~ 7.9	0	0	0	0	0			0	0	21	0	0	0	0			0	0	16	0	0	0	0			0	0	0	0	0		
8.0~ 9.9	7	0	1	0	0			0	0	188	0	0	0	0			0	0	18	0	0	0	0			0	0	0	0	0		
10.0~11.9	94	0	18	0	0			0	0	263	0	0	0	0			2	0	50	0	0	0	0			4	0	0	0	0		
12.0~13.9	124	0	95	0	0			0	0	110	0	4	0	0			5	0	59	0	1	0	0			5	0	3	0	0		
14.0~15.9	103	0	217	7	22	3.2	0.1	9	0	41	0	26	2	41	7.7	1.6	26	0	51	0	20	0	0			18	0	8	1	1	12.5	0.1
16.0~17.9	11	0	171	28	761	16.4	4.5	68	0	1	0	90	12	130	13.3	1.4	49	0	6	0	21	2	21	9.5	1.0	12	0	12	1	1	8.3	0.1
18.0~19.9	0	0	158	31	192	19.6	1.2	65	0	1	0	107	27	197	25.2	1.8	25	0	0	0	54	17	694	31.5	12.8	7	0	4	1	1	25.0	0.3
20.0~21.9	0	0	110	27	176	24.6	1.6	120	0	0	0	73	26	480	35.6	6.6	41	0	0	0	49	7	333	14.3	6.8	8	0	4	1	1	25.0	0.3
22.0~23.9	0	0	92	13	81	14.1	0.9	25	0	0	0	22	6	13	27.2	0.6	12	0	0	0	33	3	3	9.1	0.1	4	0	0	0	0		
24.0~25.9	0	0	58	6	17	10.4	0.3	66	0	0	0	33	1	1	3.0	0.0	39	0	0	0	3	2	3	66.6	1.0	0	0	0	0	0		
26.0~27.9	0	0	111	1	1	0.9	0.0	36	0	0	0	24	1	1	4.2	0.0	23	0	0	0	0	0	0			0	0	0	0	0		
28.0~29.9	0	0	15	0	0			0	0	0	0	1	0	0			1	0	0	0	0	0	0			0	0	0	0	0		
Unknown	24	0	43	3	8			22	0	26	0	10	4	6			0	0	50	0	24	1	1			10	0	0	0	0		

mackerel larvae were collected, to the number of total stations, at wich net-tows were made, and the number of mackerel larvae per tow are shown in figure 15 altogether throughout the above four regions. Namely, mackerel larvae (in this case, they may be expected, from the geographical point of view, that they are all the larvae of "hon-saba") occur, gradually in the large number, in the season when the water temperature continues to rise from 14° to 21°C., and dwindle away abruptly over 21°C., disappearing entirely over 27°C..

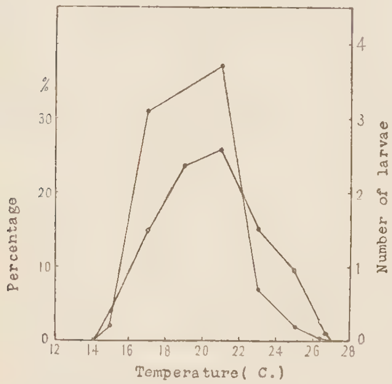


Fig. 15 The ratio of the number of stations, at which larvae were obtained, to the number of stations towed, by surface water temperature (thick line).
The number of larvae per tow by surface water temperature (fine line).

Table 7 also demonstrates that the surface water temperature in each of the four regions is lower than the above occurrence temperature range during from January to the time of beginning of the larvae occurrence. While the surface water temperature during the period from the close of larvae occurrence to the year-end is equivalent to the occurrence temperature range; this fact suggests that the close of mackerel's spawning would not be determined by the environmental conditions but rather by the physiological conditions of mackerel's own.

Looked in details at the appended table, on the Japan Sea side of Hokkaido of 1953 and 1954, larvae of "hon-saba" were little obtained except a few comparatively large ones only in August. While in 1955, numerous small larvae were captured unlike in 1953 and 1954; on the other hand, in the same region, the eggs of "hon-saba" began to appear abundantly in June every year. This difference should be noticed; namely, according to Motoda (1955) and Motoda & Anraku (1955), in this region the water temperature at the layer from 5 to 10 meters down, when eggs of "hon-saba" were captured later in June, was 12°C. or so. Also as stated before, the occurrence temperature range of eggs of "hon-saba" in this region is found between 13°C. and 16°C. at the surface. These facts demonstrate that the spawn of "hon-saba" in this region is laid under 14°C. or thereabout, which is the lower limits of the occurrence temperature range of mackerel larvae, as shown in table 7 and figure 15. The fact that, despite of the eggs occurrence in abundance, larvae were not at all captured, might be in close connection with the above-mentioned temperature conditions. Namely, it would be hypothesized that the mortality rate of eggs of "hon-saba" laid out in a too low temperature region will be very high and the spawning will yield little results. In 1955 the larvae of "hon-saba" occured in abundance from July on; according to Tomabeti & Wakao (1956), in this year an abnormal high air temperature kept on and in parts of Ishikari Bay the surface water temperature were

higher by 8°C. than in July of the preceding year. The temperature range of mackerel occurrence in this year, as stated above, moved to the "abnormally" higher for this bay, such as the range 15°~25°C. at the surface compared with that 13°~16°C. in normal years. But such a temperature range is almost equivalent to that of other regions, being not "abnormal" but rather "normal". Therefore, the difference in the states of the larvae occurrence between 1955 and the two preceding years may be derived from a normal beings of eggs through the high water temperature.

This hypothesis is also a matter to be examined in studying the relative gravity of spawning grounds or the fluctuations in year classes.

Then, there found no regular relation between the occurrence of mackerel larvae and the chloriniy ranges at the sea surface, unlike in the case of the surface water temperature, and the difference between the regions seems only to reflect that between the sea conditions when mackerel larvae were sampled (table 8).

5 Conclusion

Like this, from angle of the morphometric measurements of spawning mackerel and that of occurrence of mackerel larvae, the spawning grounds and the occurrence period of mackerel in the Tsushma Current regions extending from the East China Sea to Hokkaido, have been studied, and it has been made clear they agree in principle.

The density (number of organisms per tow) of mackerel larvae in the coastal regions of Kyushu is small compared with the other regions ——the main spawing grounds of "goma-saba" may be placed in the waters south of the region under General Survey on the warm Tsushima Current ——, and also it is regarded probably as an annual state that the spawning in Ishikari Bay can be little reproduced to the larvae. In this meaning, the Japan Sea side of Honshu has a very important significance for the study of mackerel population in the warm Tsushima Current regions.

6 Summary

1) This study deals with the spawning of mackerel, on the basis of the maturings in adult mackerels and of the geographical distibution of its larvae.

2) Nmber of total morphometrically measured mackerels amounts to 4,780, comprising 687 in 1953, 1553 in 1954, and 2,540 in 1955.

a : The spawning season on the Japan Sea side of Honshu are found during the period from April to August, beginning earlier in the southern region and later in the northern.

b : In the waters west of Wakasa Bay the spawn is laid mainly by 2-age group, while in that north of Noto Peninsula mainly by 3-age to 4-age group or more.

Table 8 Occurrence of mackerel larvae by the surface chlorinity(‰).

Region / Period / Item / Surface chlorinity(‰)	The Japan Sea side of Honshu										Surrounding waters of Hokkaido									
	Western region					Northern region					Japan sea side					Pacific side				
	April～August					June～August					July～August					August～September				
	A No. of total sts., at which towings were made	B No. of sts., at which larvae were obtained	C No. of larvae	B/A (%)	C/A	A	B	C	B/A (%)	C/A	A	B	C	B/A (%)	C/A	A	B	C	B/A (%)	C/A
Total	1,089	116	1,258	10.7	1.2	390	79	869	20.2	2.2	205	32	1,055	15.6	5.1	31	4	4	12.9	0.1
11.0～11.9	0	0	0			0	0	0			0	0	0			0	0	0		
12.0～12.9	0	0	0			0	0	0			0	0	0			0	0	0		
13.0～13.9	1	0	0			1	1	44	100.0	44.0	0	0	0			0	0	0		
14.0～14.9	1	0	0			5	1	4	20.0	0.8	0	0	0			0	0	0		
15.0～15.9	4	1	1	2.5	0.3	6	2	83	33.3	13.8	2	2	28	100.0	14.0	0	0	0		
16.0～16.9	7	0	0			5	3	8	60.0	1.6	1	1	2	100.0	2.0	0	0	0		
17.0～17.1	14	0	0			1	0	0			2	2	2	100.0	1.0	0	0	0		
17.2～17.3	25	0	0			3	2	6	66.7	2.0	0	0	0			0	0	0		
17.4～17.5	37	0	0			5	1	6	20.0	1.2	0	0	0			0	0	0		
17.6～17.7	33	0	0			5	1	3	20.0	0.6	1	0	0			0	0	0		
17.8～17.9	25	3	11	12.0	0.4	14	4	14	28.6	1.0	6	1	4	16.7	0.7	1	0	0		
18.0～18.1	25	3	10	12.0	0.4	14	5	278	35.7	19.9	5	3	61	60.0	12.2	4	0	0		
18.2～18.3	43	3	4	7.0	0.1	15	5	42	33.3	2.8	13	6	293	46.2	22.6	9	0	0		
18.4～18.5	51	11	21	21.5	0.4	34	8	40	23.6	1.2	31	8	557	25.8	18.0	3	0	0		
18.6～18.7	69	19	165	27.5	2.5	89	11	21	12.4	0.2	78	6	105	7.7	1.4	11	2	2	18.2	0.2
18.8～18.9	166	16	111	9.7	0.7	126	22	222	17.5	1.8	41	2	2	4.9	0.0	3	2	2	66.6	0.7
19.0～19.1	369	44	778	11.9	2.1	36	5	44	13.9	1.2	1	0	0			0	0	0		
19.2～19.3	113	9	73	8.0	0.6	3	0	0			0	0	0			0	0	0		
Unknown	106	7	84			28	8	54			24	1	1			0	0	0		

c : Spawnable adults are mainly composed of individuals more than 300 mm. in body length. The body length composition of the spawning group in the southern region of the Japan Sea side of Honshu differs remarkably from that in the northern; namely, in San'in district adults ranging from 300mm. to 349mm. in body length take up two-thirds of the spawning organisms; on the coast from Akita Pref. to Aomori Pref., they are mainly made up of organisms ranging from 400 mm. to 449 mm..

d : The maturing of mackerel in the waters adjacent to the Japan Sea——the East China Sea, the west coast of Kyushu, the Tsushima Strait, and the Japan Sea side of Hokkaido ——are also touched on here.

3) As for mackerel's larvae, 5,834 of materials, comprising total 3,177 (stations) collected on the Japan Sea side of Honshu during from January 1953, to July 1956, 1,940 in total around Kyushu, and total 717 around Hokkaido, are used.

a : The occurrence period of mackerel larvae on the Japan Sea side of Honshu extends from April to August. In June, the spawn is laid throughout the whole area of the Japan Sea.

b : Mackerel larvae begin to appear in February in the coastal regions of Kyushu including the East China Sea; April in the western region of the Japan Sea side of Honshu, and June in the northern region; July around Hokkaido. While the close is August throughout all the above-mentioned regions.

c : Diurnal migration of mackerel larvae seems to be not so remarkable as in atka-fish larvae, and also to be weaker than anchovy larvae.

d : As for the surface water temperature, mackerel larvae begin to occur when it rises to 14°C., and dwindle away abruptly when it reaches 21°C., or more, disappearing entirely over 27°C..

There found no regular relation between the occurrence of mackerel larvae and the chlorinity at the surface.

3) The density (number of organisms per tow) of mackerel larvae in the coastal regions of Kyushu is small compared with the other regions——the main spawning grounds of "goma-saba" may be situated in a water south of the region under General Survey on the warm Tsushima Current ——, and also it is regarded probably as an annual state that the spawn in Ishikari Bay can be little reproduced to the larvae. In this meaning, the Japan Sea side of Honshu has a very important significance for the study of mackerel population in the warm Tsushima Current region.

7 Literature

1. Dohi, W. (1955). *Tottori-ken enkai ni okeru ma-saba no gyokyo to kaikyo ni tsuite* (On the sea states and fishing conditions of *Scomber japonicus* Houttuyn in the coastal region of Tottori Pref.). *Collected Theses of the 3rd Symposium on the General Survey on the warm Tsushima Current.* Fish. Agency.

2. Enami, S. & H. Aikawa (1955) *Saba no seijuku chosa-yoho* (Prelim. rep. on the studies of mackerel's maturity). *Collected Theses of the 2nd Symposium on GSTC.** Fish. Agency.

3. ________________ (1956). *Saba no seijuku ni kansuru kosatsu.* (A study on the maturity of mackerel). *Collected Theses of the 3rd Symposium on GSTC.* Fish. Agency.

4. Fukataki, H. (1656). *Nihon-kai ni okeru ma-saba no sanran ni tsuite* (On the spawning of *Scomber japonicus* in the Japan Sea). *Collected Theses of the 4th Symposium on GSTC.* Fish. Agency.

5. Hayano, T. (1954). *Kyushu-seigan-kaiiki ni okeru ma-aji oyobi saba no chigyo no shutsugen, bunpu ni tsuite* (On the occurrence and distribution of *Trachurus japonicus* and mackerel on the west coast of Kyushu). *Collected Theses of the 1st Symposium of GSTC.* Fish. Agency.

6. Hiyama, Y., Y. Nose & K. Takaki. (1956). *Hon-saba to goma-saba no keitaisa ni tsuite* (On morphological differences between *Scomber japonicus* and *S. tapeinocephalus*). *Collected Theses of the 4th Symposium on GSTC.* Fish. Agency.

7. Hokkaido Reg. Fish. Res. Lab. & Hokkaido Fish. Sci. Inst. (1954). *Tsushima-danryu-kei sui-iki no kaihatsu ni kansuru kenkyu* (A study on the development in the Tsushima Current regions) -1. *Hokkaido-ku Shigen Chosa Yoho.* **7**.

8. ________________________________ (1955). *Ditto.* 2 . *Ibid.* **11**.

9. ________________________________ (1956). *Ditto.* 3. *Ibid.* **13**.

10. Imai, S. (1956). *Goma-saba no yoki ni tsuite* (On the larval stages of *Scomber tapeinocephalus*). Lecture delivered at the 5th symposium on GSTC.

11. Ito, T. (1954). *Tsushima-togan no saba ni tsuite* (On the mackerels on the east side of Tsushima Is.). *Collected Theses of the 1st Symposium on GSTC.* Fish. Agency.

12. Ito, S., K. Yamaguchi & K. Ito. (1951). Investigation of migrating fish stock in the north of the Japan Sea. *Bull. Japan Sea Reg. Fish. Res. Lab.* **1**. In

---

For publications with no English title, the Japanese title is given in italics and the translation thereof in parentheses.

*Hereinafter GSTC denotes the abbreviation for "General Survey on the Warm Tsushima Current."

Japanese.

13. Kamiya, T. (1916). The pelagic eggs and larvae of fishes in the Tateyama Bay (Pref. Chiba). *Jour. Imp. Fih. Inst.* **11** (5). In Japanese.

14. ________ (1925). The pelagic eggs and larvae of fishes on the coast of "Hokuriku" (North-western part of Japan Proper). *Jour. Impr. Fish. Inst.* **21**(3). In Japanese.

15. Kasahara, H. & H. Ito. (1953). *Saba no seitai* (Ecology of mackerel). *Fish. Sci. Ser.* **7**. Fish. Agency. In Japanese.

16. Kato, Y. (1954). *Kyoto Fu okiai no chigyo no shutsugen-jiki narabini shutsugen-keiko ni tsuite* (On the occurrence period and its tendency of larvae off Kyoto Fu). *Collected Theses of the 1st Symposium on GSTC*. Fish. Agency.

17. Kawamura, H. (1955). *Higashi-tswshima-suido ni okeru chigyo no kisetsuteki shutsugen keiko* (On a tendency in the seasonal occurrence of larval fish in the Higashi-suido of the Tsushima Strait). *Collected Theses of the 2nd Symposium on GSTC*. Fish Agency.

18. Kittaka, Z. (1955) *Wakasa-wan engan ni okeru hira-saba no gyotai-chosa-kekka ni tsuite* (Morphometric surveys of *Scomber japonicus* Houttuyn in the coastal region of Wakasa Bay). *Collected Theses of the 3rd Symposium on GSTC*. Fish. Agency.

19. Kittaka, Z. & H. Funada. (1955). *Kyoto Fu okiai no ma-saba no kansatsu—1954 nen do hon-saba gyotai-chosa kekka-ni tsuite* (Morphometric survey of *Scomber japonicus* Houttuyn off Kyoto, 1954). *Collected Theses of the 2nd Symposium on GSTC*. Fish. Agency.

20. Kokubu, S. (1954). *Tokai narabini Kyushu-seigan saba no seishoku-sen-juryo no sui-i* (The change in gonad weight of mackerel on the west coast of Kyushu and in the East China Sea). *Collected Theses of the 1st Symposium on GSTC*. Fish. Agency.

21. Kokubu, S. & M. Takahashi. (1955). *Goma-saba seishoku-sen shisu no tsuki betsu sui-i* (Monthly change in gonad index of *Scomber tapeinocephalus*). *Collected Theses of the 2nd Symposium on GSTC*. Fish. Agency.

22. Kurita, M. (1955). *Kyoto Fu okiai no ma-saba no kansatsu— —ma-saba no kaiyu— ni tsuite* (On the migration of *S. japonicus* off Kyoto). *Collected Theses of the 2nd Symposium on GSTC*. Fish. Agency.

23. Maeda, D., M. Hamada & A. Honda. (1956). *Kumamoto Ken okiai——Amakusa seikai——ni okeru ko-saba no nikushitsu-seibun ni tsuite* (Chemical composition of young mackerel off Kumamoto Pref.). *Collected Theses of the 4th Symposium on GSTC*. Fish. Agency.

24. Matsubara, K. (1955). Fish morphology and hierchy. Part 1. 1st ed., Tokyo. Ishizaki Shoten. In Japanese.

25. Morita, T. (1955). *Amami-oshima engan no ko-saba to sono raiyu ni oyobosu kaikyo*

ni tsuite (On young mackerel around Amami-oshima, Kagoshima Pref., and the influence of the sea states). *Collected Theses of the 3rd Symposium on GSTC*. Fish. Agency.

26. Motoda, S. (1955). Vertical distribution of mackerl eggs in Ishikari Bay, Hokkaido. *Bull. Fac. Fish., Hokkaido Univ.* **6**(1). In English.

27. Motoda, S. & M. Anraku. (1955). Occurrence of mackerel eggs in Ishikari Bay, Hokkaido, in June, 1954, as investigated by underway plankton catcher. *Ditto.* **6**(1). In English.

28. Murakami, S. (1954). *Tokai no saba ni tsuite* (On the mackerels of the East China Sea). *Collected Theses of the 1st Symposium on GSTC.* Fish. Agency

29. ———— (1955). *Saba gyoshu sosei no chi'ikiteki sai narabini kisetsu-teki henka ni tsuite* (On the seasonal change and the geographical difference in species composition of mackerel). *Collected Theses of the 3rd Symposium on GSTC.* Fish. Agency.

30. Murakami, S. & T. Hayano. (1956). On the number of interneural spines of mackerels from Japanese waters. *Bull. Jap. Soc. Sci. Fish..* **21**(9). In Japanese.

31. Nagasaki Pref. Exp. St.. (1955). *1-gatsu gejun～2-gatsu jojun no Tokai no chigyo oyobi gyoran*-III (Fish eggs and larvae in the East China Sea during later in January～early in February). *Dai* II *Ji Tsushima-danryu Okiai Chosa.* Mimeographed.

32. Noguchi, E. et al. (1955). Biochemical studies on some fishes of commercial importance-1,2. *Ann. Rep. Japan Sea Reg. Fish. Res. Lab.* **2**. In Japanese.

33. Odate, S. (1955). *Tsugaru-kaikyo fukin no chigyo ni tsuite* (On the larval fishes around the Tsugaru Strait). *Collected Theses of the 3rd Symposium on GSTC.* Fish. Agency.

34. Okachi, I. (1955a). *Ma-saba no seicho to nenrei* (The growth and age of *Scomber japonicus*). *Collected Theses of 2nd Symposium on GSTC.*. Fish. Agency.

35. ———— (1955b). *Nihon-kai no gyokaku saba ni tsuite* (on the mackerels caught in the Japan Sea). *Collected Theses of the 3rd Symposium on GSTC.* Fish. Agency.

36. Sano, O. & M. Tamura. (1955). *Ishikari-wan oyobi sono kin-iki no ma-saba, katakuchi-iwashi no ran, chishi no bunpu ni tsuite* (On the distribution of eggs and larvae of *S. japonicus* and *Engraulis japonicus* in and around Ishikari Bay). *Collected Theses of the 3rd Symposium on GSTC.* Fish. Agency.

37. Sano, O., M, Tamura & A. Iizuka. (1956). Concentration of mackerel eggs of the west coast of Hokkaido in association with particular diatom communities. *Bull. Hokaido Reg. Fish. Res. Lab.* **14**. In Japanese.

38. Sette, O. E. (1943). Biology of the Atlantic mackerel (*Scomber scombrus*) of North America. Part I. Early life history. *Bull. Fish and Wildlife Service,*

U. S. Dept. Interior. **50**. In English.

39. Steven, G. A. (1952). Contributions to the biology of the mackerel, *Scomber scombrus* L. III. Age and growth. J. M. B. A.. **30**(3). In English.

40. Takeshita. K. & H. Aikawa (1956). *Saba no keisoku-teki tokusei ni tsuite* (On the morphometric characteristics of *Scomber japonicus* and *S. tapeinocephalus*). *Collected Theses of the 4th Symposium on GSTC*. Fish. Agency.

41. Tamura, O. & Y. Ko. (1955). Studies on the differences between the types of *Pneumatophorus japonicus* (Houttuyn) and *P. tapeinocephalus* (Bleeker) -1. *Bull. Fac. Fish., Nagasaki Univ..* **3**. In Japanese.

42. Tanoue, T. & S. Enami. (1954). *Minami-Kyushu-kai'iki no hon-saba, goma-saba no seitai to sono gyojo* (The ecology and the fishing grounds of *Scomber japonicus* and *S. tapeinocephalus* in the waters south of Kyushu). *Collected Theses of the 1st Symposium on GSTC*. Fish. Agency.

43. Tanoue, T. (1955a). *Shi-iku goma-saba yogyo no seicho oyobi kankyo-tekio-sei* (The growth of reared larvae and its adaptation to surroundings). *Collected Theses of the 2nd Symposium on GSTC* Fish. Agency.

44. ________ (1955b). *Shi-iku goma-saba jakunengyo no seicho ni tsuite* (On the growth of reared young mackerel, *Scomber tapeinocephalus*). *Collected Theses of the 3rd Symposium on GSTC*. Fish. Agency.

45. ________ (1956). *Goma-saba jakunengyo no seicho-do* (The growth-rate of young mackerel, *Scomber tapeinocephalus* Bleeker). *Collected Theses of the 4th Symposium on GSTC*. Fish. Agency.

46. Tateishi, S. (1956). *Saba no seishokuso no soshikigaku-teki kenkyu to sanran kino koryo* (A histological study of mackerel's gonads and its spawning season). *Collected Theses of the 4th Symposium on GSTC*. Fish. Agency.

47. Tokunaga, D. (1954). *Saba no seikagaku-teki chosa* (Biochemical studies of mackerel). *Collected Theses of the 1st Symposium on GSTC*. Fish. Agency.

48. Tomabeti, H. & M. Wakao. (1956). 1955*-nen niokeru Ishikari-wan saba gyojo no kaikyo to gyokyo* (The sea states and the fishing conditions of mackerel in Ishikari Bay, Hokkaido, 1955). *Collected Theses of the 4th Symposium on GSTC* Fish. Agency.

49. Tsujita, T. (1954). *Tokai oyobi Kyushu-seiho no tairikudana-jo no kaikyo to sono seitaiteki sayo* (The sea states in the continental shelves region of the East China Sea and in the west region of Kyushu, and its ecological meanings). *Collected Theses of the 1st Symposium on GSTC*. Fish. Agency.

50. Tsukahara, H., T, Shiokawa & T, Honda. (1955). *Amakusa-seigan no ma-aji, goma-saba no seicho ni tsuite* (On the growth of *Trachurus japonicus* and *Scomber tapeinocephalus* on the west coast of Amakusa, Kumamoto Pref.). *Collected Theses of the 2nd symposium on GSTC*. Fish. Agency.

51. Uchida, K (1943). *Gyorui no seikatsu-shi gaisetsu* (A general life history of

fishes). *Kaiyo no Kagaku (Science of the Sea)*. **3**(10). In Japanese.

52. Yabe, H. (1953). The post larva and young—fish presumably identified as *Sbomber tapeinocephalus*—A preliminary report. *Contrib. Nankai Reg. Fish. Res. Lab.* **1**. In Japanese.

53. Yonemori, T & H. Aikawa. (1956). *Tsushima-danryu-sui-iki ma-saba no nenrei-satei ni tsuite* (On the age determination of *Pneumatophorus japonicus* in the Tsushima Current regions). *Collected Theses of the Symposium on GSTC*. Fish. Agency.

54. Yoshida, S. (1954). *Teradomari-kinkai ni chokaku sareru saba ni tsuite* (On the mackerels fished with lines around Teradomari, Niigata Pref.). *Collected Theses of the 1st Symposium on GSTC*. Fish. Agency.

Appended Table Contents of the monthly occurrence of

Month	Year	Around Kyushu A: No. of total sts. at which towings were made	Around Kyushu B: No. of sts. at which larvae were obtained	Around Kyushu C: No. of larvae	Around Kyushu D: Range of total length (mm.)	The Japan Sea side of Honshu, Western region A	Western region B	Western region C	Western region D	The Japan Sea side of Honshu, Northern region A	Northern region B	Northern region C	Northern region D	Ja… A
Jan.	1953	0	0	0		32	0	0		0	0	0		0
	'54	61	0	0		26	0	0		11	0	0		0
	'55	73	0	0		9	0	0		8	0	0		5
	'56	59	0	0		25	0	0		4	0	0		
Feb.	'53	0	0	0		38	0	0		2	0	0		0
	'54	49	0	0		29	0	0		0	0	0		0
	'55	43	2	2	7.4~11.0	33	0	0		84	0	0		5
	'56	38	0	0		34	0	0		7	0	0		
Mar.	'53	0	0	0		22	0	0		0	0	0		0
	'54	54	1	1	13.5	36	0	0		41	0	0		0
	'55	69	5	23	3~12.8	35	0	0		50	0	0		2
	'56	60	5	7	3.3~34	44	0	0		55	0	0		
April	'53	0				58	0	0		11	0	0		0
	'54	49	4	8	4~13	79	1	1	12	43	0	0		0
	'55	39	2	48	4~10	54	3	16	3~14	55	0	0		26
	'56	0	0	0		59	0	0		104	0	0		
May	'53	29	5	14	3.8~20.8	82	5	46	4~13	27	0	0		36
	'54	79	5	7	8~18.5	51	9	32	4~40	55	0	0		10
	'55	66	9	57	3~11.2	78	18	681	4~17	50	0	0		0
	'56	17	5	15	5~49	51	9	33	3~15	68	0	0		
June	'53	34	3	9	2.5~4.5	55	7	31	3~17	56	16	32	2.5~17	25
	'54	58	9	20	3.1~10	41	3	14	3.5~5	39	10	161	2.5~16	70
	'55	34	4	17	4~12	74	11	71	3~12	30	7	62	3~11	86
	'56	16	1	1	2.5	41	10	119	2.5~10	42	10	107	3~12	
July	'53	49	3	4	6~8.5	37	5	20	3~16	22	5	24	3~12	24
	'54	45	0	0		43	18	152	3~8	57	14	144	3~9	25
	'55	54	4	5	3.8~11.5	56	7	15	2.5~8.5	34	8	36	3~16	52
	'56					41	4	16	3~8	56	7	293	3~14	
Aug.	'53	34	1	1	15.5	45	0	0		0	0	0		34
	'54	76	2	6	4.9~8	54	6	11	3~10	9	1	9	5~14	62
	'55	50	0	0		95	0	0		45	1	1	34	8
Sept.	'53	41	0	0		26	0	0		12	0	0		0
	'54	57	0	0		55	0	0		36	0	0		0
	'55	90	0	0		33	0	0		22	0	0		18
Oct.	'53	64	0	0		52	0	0		20	0	0		0
	'54	54	1	1	7	40	0	0		26	0	0		27
	'55	43	0	0		47	0	0		14	0	0		9
Nov.	'53	62	0	0		30	0	0		10	0	0		0
	'54	68	0	0		22	0	0		22	0	0		5
	'55	100	0	0		44	0	0		17	0	0		4
Dec.	'53	46	0	0		26	0	0		8	0	0		0
	'54	38	0	0		22	0	0		27	0	0		5
	'55	42	0	0		36	0	0		7	0	0		0

mackerel larvae.

Surrounding waters of Hokkaido								
ıpan sea side			Okhotsk side		Pacific side			
3	C	D	A	B	A	B	C	D
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		15	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		32	0	0	0	0	
22	1,041	2.5〜16	41	0	0	0	0	
0	0		18	0	0	0	0	
8	12	7〜19	17	0	21	3	3	12〜15
2	2	11〜12	0	0	0	0	0	
0	0		4	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	10	1	1	10
0	0		0	0	0	0	0	
0	0		21	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	
0	0		0	0	0	0	0	

Chapter III "Buri"

(Yellow tail, *Seriola quinqueradiata* Temminck et Schlegel)

1. Preface

"Buri", *Seriola quinqueradiata* Temminck et Schlegel, is an important fish, quantitatively and economically, of the fisheries-catches in Japan.

Matsushita (1953) published general considerations on the ecology and the fisheries, on the basis of studies of "buri" that had been reported during the period 1922-1952. In this general considerations, Matsushita says —The spawning of "buri" probably starts, in the coastal waters of Kyushu, early in spring, and on the Pacific coast and on the Japan Sea side of Honshu it seems to extend to the north from spring to early summer. But, in farther southern regions, the spawning may be partially laid even in winter. He says also that hereafter these presumptions and hypothese have to be studied and examined in full.

Uchida (1954) reports the results of its artificial fertilization in which he succeeded at Mejima, a small island of Goto Islands off the west coast of Kyushu, and the maturing state of adult "buri"; Ishizu (1956) reports observations of spawning groups at the same Mejima fishing ground; and Mitani (1956) about the fecundity.

Uchida (1954, 1955), Kato (1954, 1955), Imai (1954, 1955), and Kawamura (1955) report in brief on the geographical distribution and the occurrence period of "buri" larvae, on the basis of the materials captured by horizontal tows of "maru-chi" net at the sea surface.

This thesis also deals with the spawning season and the spawning grounds in details.

2. Materials

The materials used in this thesis are the data based on the materials captured by horizontal tows of "maru-chi" net at the sea surface ; the collecting of materials was made by Kagoshima University, by five prefectural fisheries experimental stations on the west coast of Kyushu, by twelve pref. fish. exp. sts. on the Japan Sea side of Honshu, by Japan Sea Regional Fisheries Research Laboratory, and by Hokkaido Reg. Fish. Res. Lab..

Although there is a divergence on collecting periods around Kyushu, as a whole they are all contained in the period from April, 1953 to June, 1956 ; number of total stations at which towings with "maru-chi" net were made mount up to 2,013.

Of materials captured by twelve prefectures on the Japan Sea side of Honshu, materials of ten prefectures other than Yamaguchi Pref. and Kyoto Fu. and those collected by the authors were, for the most part, identified by H. Fukataki, one of the authors; but a part of materials collected before June, 1954 were identified by Prof,

Uchida and his members of Kyushu University. Materials collected by Yamaguchi Pref. and Kyoto Fu were identified respectively by the members of each pref. fish. exp. st., and the data are mimeographed.

Number of total stations in the Japan Sea region at which towings were made, reaches 3,158 during the period from January. 1953 to July, 1956; and these 3,158 samples are cited here.

As for the surrounding waters of Hokkaido, data at 717 stations in total, that Hokkaido Reg. Fish. Res. Lab. captured during May, 1953 ~ November, 1955, are also used here.

Number of total stations, at which towings were made, in the above three sea regions amount to 5,978; of these 5,978 stations, number of stations, at which "buri" larvae were captured, is 193 in total; number of larval organisms is 591 in total, considerably small number.

3. Distribution of "buri" larvae

(1) Occurrence periods

Table 1 shows number of stations by month, at which "buri" larvae were captured, and the state of its occurrence. In the neritic waters of Kyushu including the East China Sea, they appear during the period February~August; and in the southern region of the Japan Sea (the region west of Wakasa Bay), during the period

Table 1　Monthly occurrence of yellow-tail larvae.

	Around Kyushu				The Japan Sea side of Honshu								The Surrounding waters of Hokkaido	
					Western region				Northern region					
	A No. of total sts. at which towings were made	B No. of sts. at which larvae were obtained	C No. of larvae	D Range of total length of larvae (mm.)	A	B	C	D	A	B	C	D	A	B
Total	2,013	132	469	2~112	1,870	58	119	5~62	1,288	3	3	5~26	717	0
Jan.	200	0	0		92	0	0		23	0	0		5	0
Feb.	143	1	1	11	134	0	0		93	0	0		5	0
March	176	2	3	9.5~19.5	137	0	0		146	0	0		2	0
April	93	11	84	5~26	247	2	2	12, 60	219	0	0		26	0
May	202	62	224	4~112	265	12	38	8~54	194	0	0		46	0
June	144	44	142	2~70	211	21	47	5~42	167	0	0		196	0
July	173	11	14	7~33	184	15	21	7~62	169	3	3	5~26	174	0
Aug.	163	1	1	10	189	3	5	8~34	54	0	0		160	0
Sept.	188	0	0		114	2	3	12~49	70	0	0		32	0
Oct.	161	0	0		117	0	0		60	0	0		57	0
Nov.	243	0	0		96	0	0		49	0	0		9	0
Dec.	127	0	0		84	0	0		44	0	0		5	0

April~September; in the northern region of the Japan Sea (the region north of Noto Peninsula), only in July; in the surrounding waters of Hokkaido no larval form has occured all the year round.

Figure 1 shows the monthly change of the percentage① of number of stations, at which "buri" larva was obtained, to number of total stations, at which towings of "maru-chi" net were made, and number② of larvae per tow [①: B/A in table 1, ②: C/A]. According to figure 1, the best season for occurrence is from April to June in the neritic waters of Kyushu, and from May to July in the southern region of the Japan Sea side of Honshu.

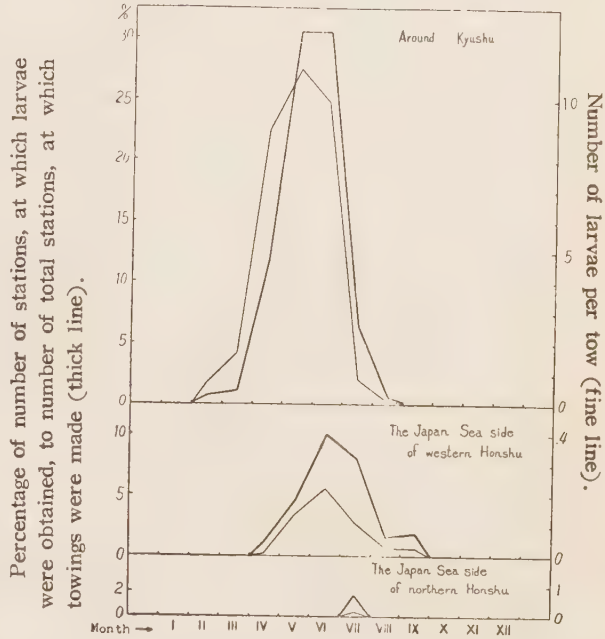


Fig. 1 Occurrence of yellow-tail larvae by month and area.

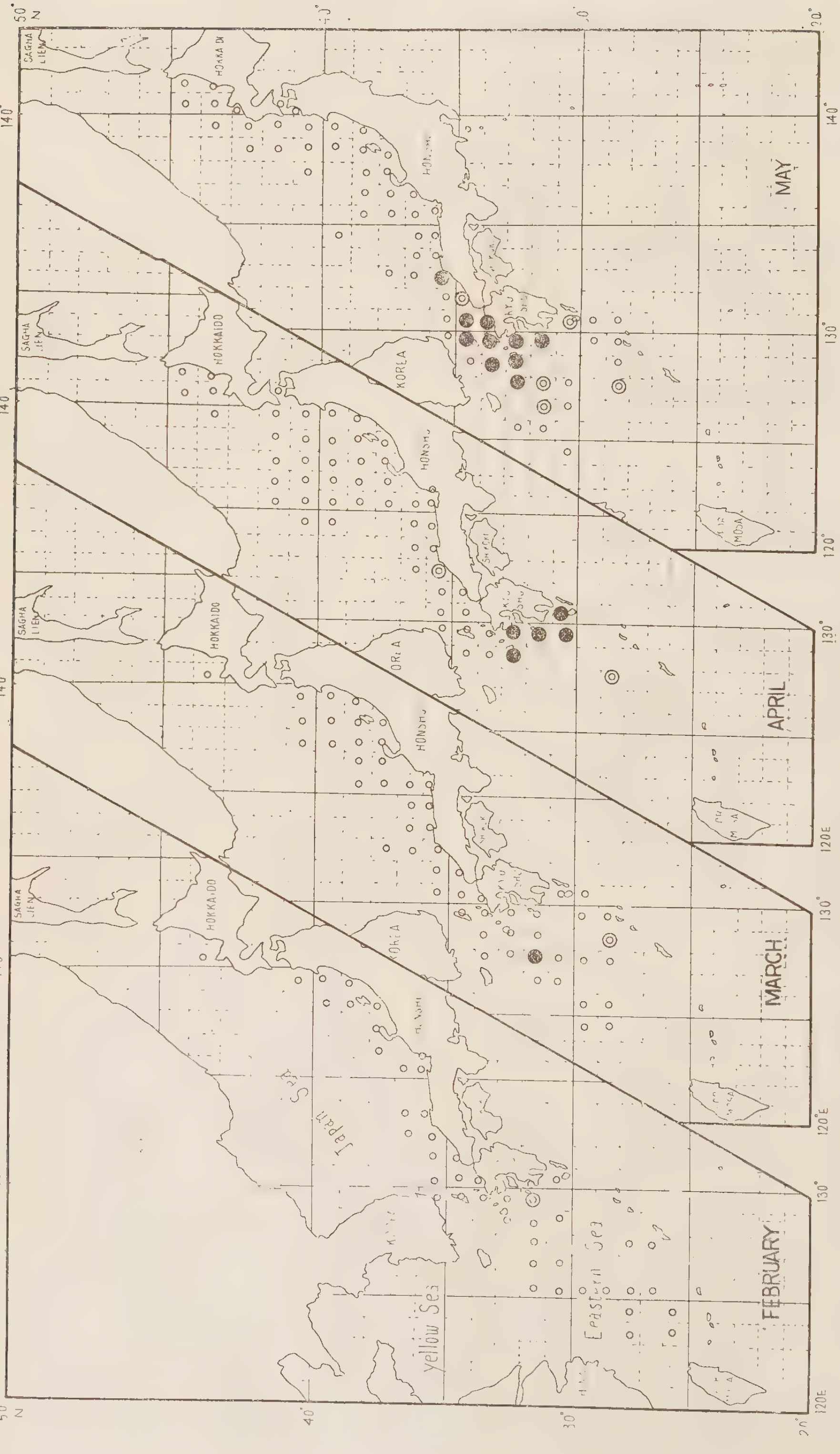
(2) Geographical distribution by month

Figures 2 and 3 show the towed region during February to September, the occurrence period and region of "buri" larvae given in 1° square of latitude and longitude. Table 2 shows the southern, northern, eastern, and western limits of the occurrence region of larvae in each month. According to these figures and table, the monthly distribution shall be stated as follows.

February: In this month only a larva has been captured on the south-west coast

Table 2 Monthly occurrence sphere of yellow-tail larvae, from angles of latitude and longitude.

Month	Southern limits		Northern limits		Western limits		Eastern limits	
	Lat. N.	Long. E.	Lat. N.	Long. E.	Lat. N.	Long. E.	Lat. N.	Long. E.
February	31°35′5	129°01′5	31°35′5	129°01′5	31°35′5	129°35′5	31°35′5	129°01′5
March	28°40′	128°55′	31°46′	127°23′	31°46′	127°23′	28°40′	128°55′
April	28°48′	127°24′	35°49′	132°39′	28°48′	127°24′	35°49′	132°39′
May	28°42′	127°04′	35°24′	132°00′	31°16′	126°35′	35°04′	132°00′
June	31°20′	127°05′	36°40′	135°26′	31°20′	127°05′	35°51′	135°26′
July	33°06′	129°10′	40°36′	139°38′5	33°06′	129°10′	40°36′	139°38′5
August	33°50′	130°00′	36°00′	135°26′	33°50′	130°00′	35°42′	135°26′
September	34°18′4	130°26′4	34°51′	130°21′4	34°51′	130°21′4	34°18′4	130°26′4



○ : Spuares at which towings were made, but no larvae were obtained.
● : Squares at which larvae smaller than 9.9 mm. in total length were obtained.
◎ : Squares at which larvae larger than 10mm. in total length were obtained.

Fig. 2 Monthly geographical distribution of yellow-tail larvae, shown 1° square of longitude and latitude—1 (February~May).

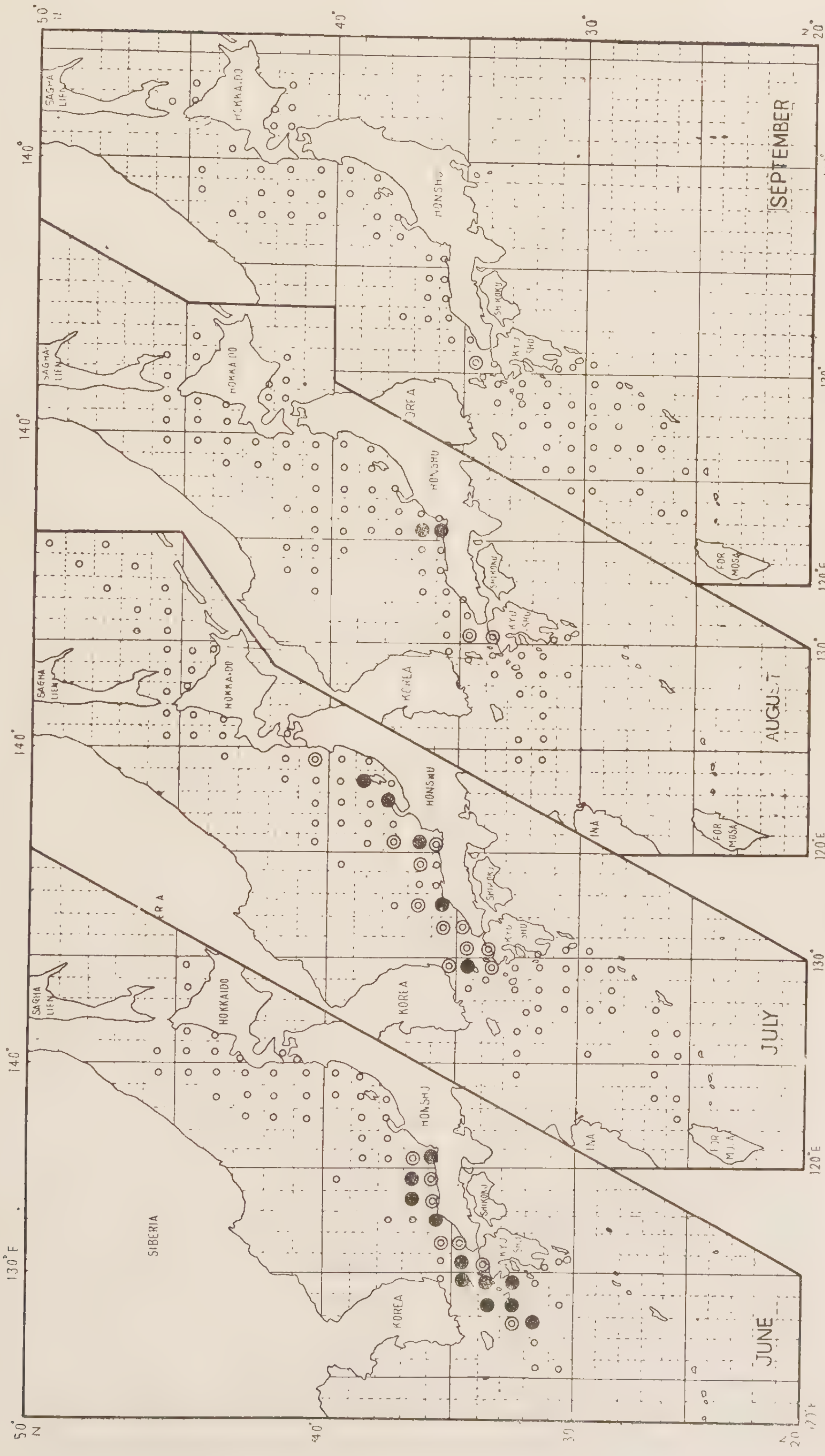


Fig. 3 Monthly geographical distribution of yellow-tail larvae, shown 1° square of longitude and latitude—2 (June~September).

of Kyushu on the 23rd of February, 1954. This is, seasonally, the earliest occurrence (the following number of larvae designates the total that has been captured during the period from January, 1953 to July, 1956).

March : At two stations between Okinawa-honto of the Riukiu Islands, and Cheju Do (Saishu-to), Korea, three larvae ranging from 9.5 mm. to 19.5mm. in total length were captured.

In the south-west waters of Kyushu, only a few larvae have been captured in these two months. In other waters no larvae have been obtained in the same period.

April : Since this month, number of larvae captured in the neritic waters of Kyushu starts to remarkably increase. The occurrence region covers the waters all over the south-west of Kyushu region, extending from Goto Islands, Nagasaki Pref., to Yaku-shima, Kagoshima Pref.. In the materials captured by "maru-chi" net, a number of larvae smaller than 10 mm. in total length are also contained. Its occurrence in offshore region can not be confirmed, as the research region in April is limited to neritic region of Kyushu. But, considering in connection with the distribution of "buri" larvae in March and May, and the fact that, toward the end of April, three larvae ranging from 12 mm. to 18 mm. in total length were captured in lat. 28°～29°N. and long. 127°～128°E., it is presumed that larvae of "buri" will be found in farther offshore region (Uchida, 1954). The northern-most (eastern-most) end of geographical distribution is placed off Shimane Pref., and early in April a larva 12 mm. long and late in April a larva 60 mm. long were captured off Shimane Pref..

May : The general scope of distribution is probably the same as April. But the distribution region of smaller larvae 10 mm. long and less becomes wider compared with that of April, covering all over the waters extending from region west of southern Kyushu to the Chosen Strait. In May, both number of total larvae and of larvae per tow show the largest value in the course of year.

June : The distribution region, as a whole, goes north, covering the waters from offshore region of the Amakusa Islands to Wakasa Bay, and, in the neritic region of southern Kyushu, no larva is captured. Smaller larvae 10 mm. and less occur consecutively along the west coast of Kyushu, but on the Japan Sea side of Honshu its occurrence region is to some extent intermittent. From June on, number of larvae captured by "maru-chi" net begins to decrease.

July : The distribution region, as a whole, continues to go north compared with June, covering the waters from the Chosen Strait to Aomori Pref.. The occurrence of larvae smaller than 10 mm. in total length geographically intermittent, being found chiefly around the Tsushima Islands, off Shimane Pref., in Wakasa Bay, in Toyama Bay, and around Sado Island.

August : Larvae of "buri" are little obtained throughout the whole Japan Sea— only 6 larvae have been obtained in Wakasa Bay and the Tsushima Strait. Of these 6 larvae, three larvae are comparatively large, ranging 32 mm. to 34 mm. in total length.

September : Early in September, only 3 larvae have been obtained (in the Tsushima Strait). Of these, two larvae are 48~49 mm. in total length.

4. Total length composition of larvae

In some occasions, census measurement for all materials has not been made, but the range of total length (the largest and the smallest value) at each station was measured. So that, when larvae more than three organisms were captured, there are frequent occasions when the precise length of the rest other than the largest and the smallest organisms has not been known. Figure 4 shows the total length composition

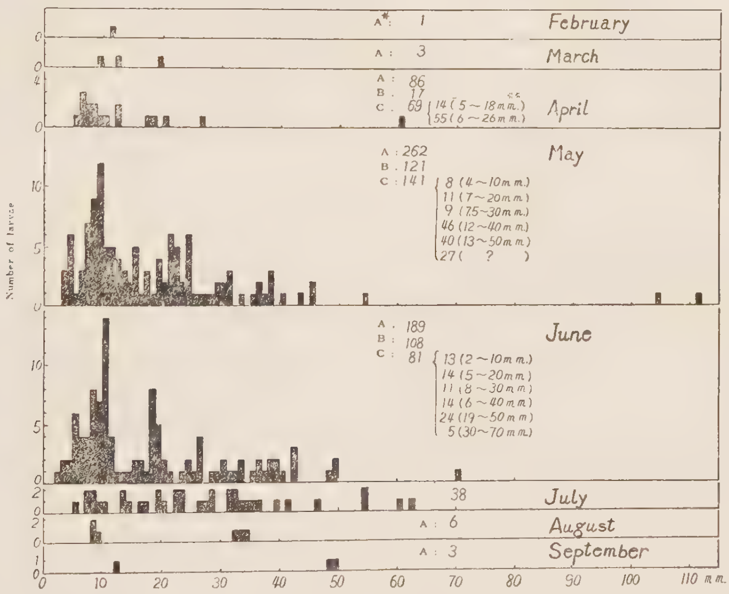


Fig. 4 Frequency of total length of yellow-tail larvae caught with "maru-chi" net.

* A : Number of total larvae which caught with "maru-chi" net.
B : Number of larvae which total length was measured.
C : Number of larvae which individual total length was not measured.
** Arabic numerals in parentheses denote the range of total length.

of larvae alone that their total lengths were measured. According to the above cause, number of larvae which total lengths were unknown is 69 in April, 141 in May, and 81 in June. Consequently, in figure 4, the positions of mode in histogram during April~June may be to some extent different from the actual position. But the range is the same as the actual position.

According to firgue 4, the majority of captured larvae extends from the minimum length just after their hatch to 50 mm. in total length, and distribution of total length is nearly consecutive. Larvae larger than 50 mm. in total length are seldom captured. The largest "buri" larvae captured by "maru-chi" net are 104 mm. and 112 mm. (captured in May, around Goto Is.).

As to the monthly change of total length composition, during February and March, larvae are smaller than 20 mm.; from April on, larvae larger than 50 mm. are rarely captured; during April～June, smaller larvae less than 20 mm. are consecutively captured in large number; from July on, number of larvae decreases, increasing in number of comparatively large larvae more than 20 mm.

5. Occurrence by time

The upper row of table 3 shows the percentage of number of stations, at which "buri" larvae were obtained, to number of total stations, at which towings were made, and number of larvae per tow, by time. Considering geographical differences of towed times, it is hard to take out that number of larvae captured by daytime differs from that by night. On the basis of a well-known fact that "buri" larvae drift or swim with floating seaweeds, it is estimated that they make no remarkable, vertical diurnal migration.

6. Relation between the occurrence of larvae and the sea conditions

The middle row of table 3 shows the percentage of number of stations, at which "buri" larvae were obtained, to number of total stations, at which towings were made, and number of larvae per tow, by surface water temperature. The temperature range for their occurrence is from 14° to 29°C. level in the coastal regions of Kyushu, and 14° to 27°C. level on the Japan Sea side of Honshu. Water temperature range for the best efficiency is nearly the same in these two regions, ranging from 18° to 21°C. level in the former, 18° to 23°C. level in the latter. As the optimum temperature for "buri" fishing is from 14° to 17°C., its larvae occur in the range higher than its adults. It is a well-known fact that, in the various places along the Japan Sea side of Honshu, adults caught in "buri" fisheries of spring are larger early in the fishing season, and becomes smaller with the process of season. Consequently, it should be given as a conclusion that the more "buri" is young, the more it lives in high water temperature waters.

Table 4 shows monthly change of the ranges of surface water temperature and surface chlorinity, when "buri" larvae were obtained. As for water temperature, on the west coast of Kyushu, there found no remarkable difference during April-June, the best time for the occurrence of "buri" larvae. But, on the Japan Sea side of Honshu, it continues to rise over the whole occurrence period from April to August.

The lower row of table 3 shows the percentage of number of stations, at which larvae were captured, to number of total stations, at which tows were made, and number of larvae per tow, by range of surface chlorinity. "Buri" larvae, in Kyushu region, are captured only in the waters more than 17.00 Cl ‰, and, in the southern region (west of Wakasa Bay) of the Japan Sea, they are captured only in the waters more than 17.50 Cl ‰. In Kyushu region, its prosperity is placed in the waters more

Table 3 Occurreence of yellow-tail larvae by time, surface water temperature and chlorinity.

		Around Kyushu					The Japan Sea side of Hnnshu									
							Western region					Northern region				
		February~August					April~September					July				
		A No. of total sts., at which towings were made.	B No. of sts., at which larvae were obtained.	C No. of larvae	B/A (%)	C/A	A	B	C	B/A (%)	C/A	A	B	C	B/A (%)	C/A
Total		1,094	132	469	12.1	0.4	1,210	58	119	4.8	0.1	169	3	3	1.7	0.0
Time	00:00~05:59	91	9	27	9.9	0.3	153	7	13	4.6	0.1	28	1	1	3.6	0.0
	06:00~11:59	403	55	180	13.7	0.4	399	18	28	4.5	0.1	66	2	2	3.0	0.0
	12:00~17:59	459	58	170	12.7	0.4	465	26	68	5.6	0.1	46	0	0		
	18:00~23:59	129	10	92	7.8	0.7	165	2	3	1.2	0.0	29	0	0		
	Unknown	12	—	—			28	2	4	7.1	0.1	0	0	0		
Surface temprature (°C.)	8.0~ 9.9	2	0	0			1	0	0			0	0	0		
	10.0~11.9	9	0	0			18	0	0			0	0	0		
	12.0~13.9	88	0	0			95	0	0			0	0	0		
	14.0~15.9	180	1	1	0.6	0.0	217	1	1	0.5	0.0	1	0	0		
	16.0~17.9	124	8	47	6.5	0.4	171	7	8	4.1	0.0	21	0	0		
	18.0~19.9	148	53	158	35.8	1.1	158	14	49	8.9	0.3	55	0	0		
	20.0~21.9	150	56	181	37.4	1.2	110	12	25	10.9	0.2	58	2	2	3.4	0.0
	22.0~23.9	74	6	62	8.1	0.8	100	10	15	10.0	0.2	20	1	1	1.6	0.0
	24.0~25.9	84	2	2	2.4	0.0	122	5	7	4.1	0.1	8	0	0		
	26.0~27.9	80	0	0			152	2	3	1.3	0.0	5	0	0		
	28.0~29.9	82	1	1	1.2	0.0	16	0	0			0	0	0		
	30.0~31.9	6	0	0			0	0	0			0	0	0		
	Unknown	67	5	17	7.5	0.3	50	4	8	8.0	0.2	1	0	0		
Surface chlorinity (‰)	11.00~11.99	1	0	0			0	0	0			0	0	0		
	12.00~12.99	0	0	0			0	0	0			0	0	0		
	13.00~13.99	1	0	0			1	0	0			0	0	0		
	14.00~14.99	1	0	0			1	0	0			5	0	0		
	15.00~15.99	3	0	0			4	0	0			6	0	0		
	16.00~16.99	21	0	0			7	0	0			4	1	1	2.5	0.0
	17.00~17.49	62	2	2	3.2	0.0	62	0	0			2	1	1	50.0	0.5
	17.50~17.99	90	6	13	6.7	0.1	128	6	9	4.7	0.1	10	0	0		
	18.00~18.49	102	10	45	9.8	0.4	139	6	10	4.3	0.1	21	0	0		
	18.50~18.99	189	38	84	20.1	0.4	261	18	36	6.9	0.1	101	1	1	1.0	0.0
	19.00~19.49	548	64	292	11.7	0.5	48	20	52	41.9	1.8	17	0	0		
	Unknown	76	12	33	15.8	0.4	125	5	9	4.0	0.1	3	0	0		

Table 4 Change in surface water temperature and chlorinity where yellow-tail larvae occur, by month and region.

Region / Month	Surface temperature		Surface chlorinity	
	Around Kyushu	The Japan Sea side of southern Honshu	Around Kyushu	The Japan Sea side of southern Honshu
February	10—22 °C. **21—22**		18.0—19.4 ‰ **19.4**	
March	9—23 **22**		17.9—19.4 **19.2**	
April	13—23 **17—22**	9—17 °C. **14—16**	18.8—19.3 **18.8—19.2**	13.0—19.4 ‰ **19.1—19.2**
May	13—25 **14*—23**	12—19 **16—19**	17.1—19.3 **17.4—19.3**	17.6—19.3 **18.9—19.2**
June	18—24 **18—22**	15—23 **17—23**	15.0—19.1 **17.5—19.1**	18.2—19.4 **18.6—19.2**
July	20—29 **20—24**	17—29 **19—24**	14.0—19.1 **17.9—19.1**	15.0—19.2 **17.5—19.0**
August	23—30 **29**	22—28 **24—25**	11.0—18.9 **17.2**	16.0—18.7 **17.5—18.4**
September		23—27 **26—27**		17.3—18.5 **17.5—17.8**

Ordinary-type numerals designate the range at the total stations, at which towings were made.
Gothic-type numerals designate that at stations, at which yellow-tail larvae were captured.
* The range in which larvae occur in May is from 16° to 23°C., except a single station where it is 14°C..

than 18.50 Cl ‰; in the southern region of the Japan Sea it is placed in the waters more than 19.00 Cl ‰. These values are saltier than those of anchovy and mackerels as stated in respective chapter. Namely, "buri" larvae probably live in comparatively saltier waters, to some extent selectively.

But seeing the monthly change of chlorinity range in which larvae occur, especially in the southern region of the Japan Sea, the occurrence of "buri" larvae tends to remove to less salty region, in course of time. This is related to a fact that, during spring and summer, chlorinity in this region decreases owing to mixing with the river of Asia Continent.

7. Consideration on spawning seasons and spawning grounds

On grounds of past reports and results gotten in clause 3, 4, and 6 of this thesis, the authors will here discuss on spawning season and spawning ground of "buri".

"Buri" begin to spawn about the middle of February on the west coast of Kyushu; the heavy spawning in this region is found during late in March to June. This coincide perfectly with past studies. It is probably a fact that, before early in February, "buri" does not spawn, with a little reservation in farther southern region beyond the waters covered by this survey.

The spawning on the north coast of Kyushu begins toward the end of April or early in May, continuing probably till July.

It is trustworthy that the northern-most end of spawing ground in the Japan Sea

reaches around Wakasa Bay. Also in Toyama Bay a little spawn may be laid. For this, there is a good reason as folllows.

In Toyama Bay and around Sado Island, larvae 8 mm. and 5 mm. long were obtained in July (table 5). On the other hand, according to Uchida (1954), "buri" larva just after hatch is 3.48 mm. long, reaching 3.85 mm. in total length three days after, when yolk sac has been absorbed. Therefore, the larvae 5 mm. or 8 mm. long should be organisms that lived only short days after their hatch. After all, the drift distance out of their spawning ground should not be so long.

Table 5 Records of larvae collected on the Japan Sea side of Honshu.

Date	Location Lat. (N°)	Location Long. (E°)	No. of larvae	Range of total length (mm.)	Pref.
Ⅳ-2 '54	35°49′	132°39′	1	12	Shimane
Ⅳ-23 '54	35 15	132 00	1	60	〃
Ⅴ-13 '53	34 43	129 39	1	10	Yamaguchi
〃	34 51	129 34	1	8	Shimane
〃	〃	129 44	1	9	Yamaguchi
Ⅴ-13 '56	34 56	131 58	2	38, 54	Shimane
Ⅴ-15 '53	34 58	129 42	1	18	Yamaguchi
Ⅴ-27 '53	34 59	132 00	3	?	Shimane
〃	35 04	〃	1	?	〃
〃	35 24	〃	24	?	〃
Ⅴ-28 '54	34 56	〃	1	9	〃
〃	35 06	〃	1	19	〃
〃	35 16	〃	1	19	〃
〃	35 21	〃	1	15	〃
Ⅵ-1 '55	35 06	〃	3	30,36,38	〃
Ⅵ-2 '55	34 45	130 31	2	25, 37	Yamaguchi
Ⅵ-3 '55	34 46	131 32	2	16, 18	〃
〃	35 27	131 03	9	11~33	〃
Ⅵ-5 '54	35 55	134 18	1	42	Tottori
Ⅵ-11 '53	35 51	135 26	3	8~10	Kyoto
Ⅵ-15 '54	34 56	132 00	4	10~24	Shimane
〃	35 06	〃	2	21~40	〃
Ⅵ-16 '55	35 18	132 26	1	8	〃
Ⅵ-17 '55	35 44	132 28	1	10	〃
〃	35 58	132 53	1	39	〃
Ⅵ-18 '55	36 21	133 27	2	5	〃
Ⅵ-20 '55	34 59	131 53	2	26, 42	〃
〃	35 19	131 24	1	13	〃
Ⅵ-20 '53	35 40	133 20	1	33	Tottori
〃	35 58	133 20	1	35	〃
Ⅵ-22 '54	34°59′	131°53′	1	24	Shimane
Ⅵ-24 '53	36 02	134 40	4	6~39	Kyoto
Ⅵ-25 '53	36 15	134 34	2	12~28	〃
Ⅵ-26 '53	36 40	135 26	1	42	〃
Ⅵ-? '54	?	?	3	23,26,33	Shimane
Ⅶ-1 '55	35 10	129 53	1	32	Yamaguchi
〃	35 26	132 00	3	27,31,41	Shimane
〃	38 13	138 42	1	5	Niigata
Ⅶ-2 '55	34 28	131 10	1	15	Yamaguchi
Ⅶ-2 '56	35 51	135 26	1	35	Kyoto
Ⅶ-2 '55	36 15	134 47	1	31	Hyogo
Ⅶ-2 '54	36 54	136 05	1	34	〃
Ⅶ-4 '53	37 20	135 26	1	62	Kyoto
Ⅶ-7 '55	40 36	139 39	1	26	Aomori
Ⅶ-8 '55	35 29	132 23	3	46,54,54	Shimane
Ⅶ-9 '53	35 30	132 38	1	7	〃
〃	35 43	132 46	1	60	〃
Ⅶ-9 '55	36 44	132 57	1	32	〃
Ⅶ-10 '56	36 05	135 34	3	20,28,36	Hyogo
Ⅶ-13 '53	35 42	135 26	1	16	Kyoto
Ⅶ-14 '53	35 06	131 44	1	39	Shimane
Ⅶ-17 '53	37 25	137 30	1	8	Toyama
Ⅶ-28 '54	36 11	135 33	1	8	Hyogo
Ⅷ-2 '54	35 42	135 26	1	8	Kyoto
〃	36 00	135 26	1	8	〃
Ⅷ-6 '54	34 32	130 50	3	32~34	Yamaguchi
Ⅸ-5 '54	34 18	130 26	2	48, 49	〃
Ⅸ-8 '54	34 51	130 21	1	12	〃

But larvae captured off Aomori Pref. are 26 mm. in total length. As it requires considerable long time to reach this total length, it can not be considered that its spawn is laid in this region.

The bulk of spawned eggs in the Japan Sea is laid during from May to July (the best season is June), a little spawn may be laid even in August. Though there are records that, even in September, "buri" larvae were captured, considering its total length, they are surely derived from the spawning before August.

Owing to imperfectness in collecting with "maru-chi" net, it is unable to make a strictly quantitative consideration. But on grounds of length of occurrence period of larvae, frequency of occurrence, and number of larvae per tow, the main spawning ground of "buri" is regarded as Kyushu region; and the southern region of the Japan Sea will corresponds to its outskirts.

8. Summary

1) "Maru-chi" net materials (stations) obtained in General Survey on the Warm Tsushima Current amout to 5,978 in total (January, 1953～July, 1956). This thetis deals, using these data, with the spawning season and the spawning ground of "buri" (yellow tail).

2) "Buri" larvae are captured during the period from Febuary to August in Kyushu region, and from April to September on the Japan Sea side of Honshu. The best season is April to June, and May to July, respectively.

3) The geographical scope of distribution is also treated.

4) Total length of "buri" larvae captured by "maru-chi" net ranges between 3.5 mm. (just after hatch) and 112 mm.. Total length composition of larvae smaller than 50 mm. is consecutive. The bulk of larvae is composed of those smaller than 20 mm..

5) Surface water temperature in which "buri" larvae are captured ranges from 14° to 29°C.; the best efficiency is found at 20°C. and thereabout. Surface chlorinity for the occurrence of "buri" larvae is always over 17.50 ‰; the best efficiency is found over 18.50 ‰.

6) Spawning of "buri", on the west coast of Kyushu, starts toward the middle of February, continuing till August. The main spawning season is the period from April to July. The main spawning ground is the neritic waters of Kyushu, and the southern region (the waters west of Wakasa Bay) of the Japan Sea corresponds to its outskirts. It is sure that the northern-most end of the spawning ground lies in Wakasa Bay; on the other hand, spawn may be little laid in Toyama Bay.

9. Literature

1. Higashida, I. & A. Minamizawa. (1956). *Wakasa Wan no buri ni tsuite* (On yellow tail, *Seriola quinqueradiata* T. & S., in Wakasa Bay). *Collected Theses of the 4th Symposium on GSTC.** Fish. Agency.

2. Imai, S. (1954). *Kagoshima Ken seiho oyobi nanpo kai-iki ni arawareta chigyo no gaikan* (Notes on larval fishes in the waters west of Kagoshima Pref. and in the southern sea). *Thushima-danryu Kaihatsu Chosa Shiryo*-1 (Data of GSTC). *Kagoshima Univ.*.

3. ______ (1955). *Satsunan Kai-iki de saishu sareru gyoran narabini chishi no gaikan* (An outline on fish eggs and larval forms in the waters of southern Kagoshima Pref.). *Ibid.* 2.

4. Ishizu, T. (1956). *Mejima-gyojo kaiyu buri no tokusei ni tsuite* (On the characteristics of migrating yellow tail in Mejima fishing ground). *Teichi* (Settle-net fishery). 8, Nihon Teichi Gyogyo Kyokai, Tokyo.

5. Kato, Y. (1954). *Kyoto Fu okiai no chigyo no shutsugen-jiki narabini shutsugen keiko ni tsuite* (The occurrence period and the occurrence trend of larval fishes off Kyoto Fu). *Collected Theses of the 1st Symposium on GSTC*, Fish. Agency.

6. ______ (1955). *Kyoto Fu okiai no gyoran, chigyo ni tsuite* (On fish eggs and larval fishes off Kyoto Fu). *Collected Theses of the 2nd Symposium on GSTC*, Fish. Agency.

7. Kawamura, H. (1955). *Higashi Tsushima Suido ni okeru chigyo no kisetsu-teki shutsugen keiko* (Seasonal occurrence of larval fishes in the Higashi Suido of Tsushima Strait). *Ibid.*

8. Matsushita, T. (1953). *Buri to sono gyogyo* (Yellow tail and its fisheries). *Gyogyo Kagaku Sosho*-Fish. Sci. Ser. 6. Fish. Agency.

9. Mitani, F. (1956). *Buri no seishokuso ni tsuite* (On the gonad of yellow tail). *Teichi* (Settle-net fishery). 10, Nihon Teichi Gyogyo Kyokai, Tokyo.

10. Uchida, K. (1954). *Tsushima-danryu kai-iki no fuyu-gyoran, chishi* (On the pelagic fish eggs and larval fishes in the warm Tsushima Current regions). *Tsushima-danryu Kaihatsu Chosa Kenkyu Hokoku*-1 (Bull. of GSTC). Fish Agency.

11. ________ (1955). *Tsushima-danryu kai-iki ni okeru juyo gyorui chishi no bunpu to shutsugen-ki* (The geographical distribution and the occurrence period of important fishes' larvae in the warm Tsushima Current regions). *Collected Theses of the 3rd Symposium on GSTC*. Fish. Agency.

For publications with no English title, the Japanese title is given in italics and the translation thereof in parentheses.

* Hereinafter GSTC denotes the abbreviation for "General Survey on the Warm Tsushima Current".

Chapter IV "Hokke"

(Atka fish, *Pleurogrammus azonus* Jordan et Metz)

1 Preface

Atka-mackerel or atka-fish is well known as "hokke" in Japan. "Hokke" distribute abundantly around Hokkaido, also on the Japan Sea side of Siberia, the east coast of Korea and along the coast of northern Honshu, both on the west and east.

Against remarkable decreasing of herring catch around Hokkaido of late years, the catch of "hokke" has increased intensely, especially since about 1940, having been one of the important catches; the average of annual catch of "hokke" around Hokkaido was only 700,000～1,000,000 Kan (I Kan=3.75 Kg.) during the period 1910～1939, but it has increased remarkably since 1940, exceeding 20,000,000 Kan in 1946. Thereafter it decreased down to about 10,000,000 Kan till 1950, but in the last five years it has again maintained the higher level of annual catch (30,000,000～40,000,000 Kan) (table 1).

Table 1 Production of atka-fish by year, in Hokkaido.

unit : 1,000 kan (=3.75 metric tons)

Year	Average annual landing	Year	Landing	Year	Landing	Year	Landing
1910～'14	684	1940	2,373	1946	21,371	1952	34,913
1915～'19	1,018	1941	6,236	1947	16,353	1953	41,627
1920～'24	872	1942	7,599	1948	15,341	1954	29,766
1925～'29	784	1943	11,782	1949	10,497	1955	30,054
1930～'34	833	1944	16,367	1950	10,619		
1935～'39	1,082	1945	19,091	1951	31,531		

The best fishing ground of "hokke" in Japan is the surrounding waters of Hokkaido, at which the catch is always more than 95 per cent of grand total catch in Japan. Especially it is caught abundantly on the west coast and the Okhotsk side of Hokkaido. Namely following four fishing grounds constitute the major part of the catch of "hokke" and are abundant in the named order.

i) the west coast (the Japan Sea side) and the Okhotsk side of Hokkaido.

ii) the Pacific side of Hokkaido.

iii) the west coast coast (the Japan Sea side) of northern Honshu.

iv) the east coast (the Pacific side) of northern Honshu.

The southern-most end of commercial landing is Ishikawa Pref., on the west coast of Honshu and Miyagi Pref., on the Pacific side of Honshu (fig. 1, table 2).

Although the fishing season of "hokke" in the best fishing ground—the aforementioned i)— is found throughout the year, the best season is spring (April～May) and

Table 2 Production of atka-fish by area and month in 1955.

unit : 1,000 kan(=3.75 metric tons).

Month	Total	Surrounding waters of Hokkaido				Northern Honshu	
		Sub-total	Japan Sea side	Okhotsk Sea side	Pacific side	Japan Sea side	Pacific side
Ann. total	30,332	30,054	11,659	16,598	1,796	219	58
Jan.	1,489	1,459	657	717	84	7	22
Feb.	500	473	258	144	70	17	9
Mar.	1,115	1,070	602	292	175	31	13
April	1,806	1,766	1,077	71	617	33	6
May	2,888	2,870	1,007	1,225	637	15	0
June	965	930	338	563	27	35	0
July	331	325	161	119	45	5	0
Aug.	215	214	83	129	1	0	0
Sept.	528	528	231	295	1	0	0
Oct.	6,846	6,840	1,983	4,853	4	5	0
Nov.	9,265	9,228	2,278	6,872	77	36	0
Dec.	4,381	4,346	2,979	1,312	53	30	4

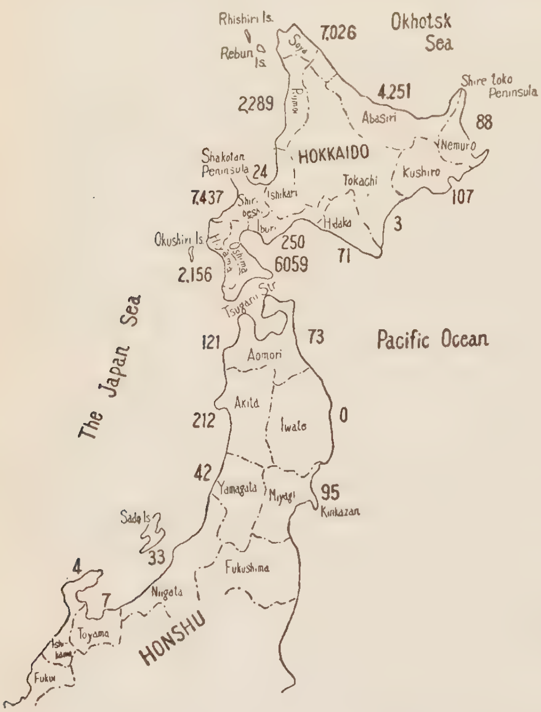


Fig. 1 Landings of atka-fish by area in 1954.
(unit : 1,000 kan=3.75 metric tons)

autumn (October~December). The best fishing season on the Pacific side of Hokkaido and on the west coast of northern Honshu are found also in spring and autumn, but in summer, the catch of "hokke" decreases down to nearly nothing. The fishing season on the pacific side of northern Honshu is limited in three or four months, the lowest water temperature period in the year (table 2).

The two-thirds or more of the commercial landing of "hokke" in Hokkaido are caught in trawl nets for young "hokke" (especially the youngs are caught mainly on the Okhotsk side of Hokkaido), and the catch in "kogibiki-ami,"one of square-lift-nets, for adult "hokke" on the west coast of Hokkaido in spring ranks next to it; it is caught also in fixed nets, small bottom fixed nets, gill nets, long lines and so. On the west coast of northern Honshu "hokke" are caught mainly by trawl nets; long lines and surrounding nets are in the second place (table 3).

Table 3 Production of atka-fish by gear (1955).

unit : 1,000kan (=3.75 metric tons)

Gear \ Region	Hokkaido	Northern Honshu	
		Japan Sea side	Pacific side
Total	30,054	219	58
Trawl net	23,619	137	57
Square lift net	2,425	0	0
Gill net	1,356	13	0
Set net	988	12	0
Long line	543	27	0
Angling	406	4	0
Purse seine	314	23	0
Others	183	0	0

Biometrical study of "hokke" has been continued systematically since 1951, mainly by Hokkaido Regional Fisheries Research Laboratory. The study contains body length composition of catch by systematic sampling, racial investigation, maturity and spawning conditions, development of eggs, distribution of larvae and youngs, growth and age, migrating route by tagging experiment, feeding habits, landing statics, hydrographic conditions, fishing grounds and so like. On the west coast of northern Honshu systematic sampling in the catch at Ajigasawa, Aomori Pref. and spot sampling (body length composition, sex ratio, feeding habits and the like) at Niigata have been made only preliminarily.

The authors have studied the early life history of "hokke" on the basis of records on the samplings with "maru-chi" net for larvae and eggs since 1953; the geographical distribution of "hokke" larvae has been clarified, moreover found to modificate the existing interpretation on the growth of early stages. This modification probably produces a powerful effect on the analytical research of stock fluctuation of "hokke" and on the prediction of fishing conditions.

2 Summary of previous researches on reproduction

1) Size at first maturity

The biological minimum size of "hokke" has been deduced at about 27 cm., judging from the fact that the minimum body length of adult "hokke" in spawning season around Hokkaido is 26～27 cm.. This body length, in the existing interpretation, corresponds with full three years group, and it has been estimated that at least a part of this age group begins to spawn (Takemura, 1952; Hokkaido Fish. Sci. Inst., 1953; Hokkaido Reg. Fish. Res. Lab., 1956).

2) Maturity of ovarian eggs

Kambara (1950) reported that the sex of "hokke" is possible to be distinguished by gonad already in the young of 110～156 mm in body length. According to ovarian

investion on the west coast of Hokkaido during from June to December, the increase of ovarian weight and the maturing of ovarian eggs take place just befor the spawning (Kambara, et al, 1953). And it is assumed that the elder group matures, seasonally, to some extent, earlier thân the younger group (Takemura, 1952).

3) **Multiple spawning**

Takemura (1952) reported that there are two modes (1.5 mm. and 2.5 mm.) in the frequency distribution of the diameters of the wèll matured ovarian eggs, and Kambara et al. (1953) that there are five modes in it before spawning season, and assumed that the larger three modes mature, and the eggs are deposited three times in one month; but a part of matured eggs and of maturing eggs are absorbed without being spawned. Namely, at present it is estimated that as many other fishes, "hokke" is also one of multiple spawning ones.

4) **Fecundity**

Hirano (1947) reported that number of matured eggs contained in a female "hokke" with 40 cm. in total length and 500 gr. in body weight, is 4,000~5,000, and Takemura (1952 b) that it with 200~600 gr. body weight is 7,000~24,000. Hokkaido Fish. Sci. Inst. (1953) assumed that as number of eggs laid at a time by a female is about 4,000 and number of times of spawnings is three, number of eggs laid by a female is about 12,000.

5) **Spawning seasons and grounds**

According to Hirano (1947), Hirano and Takahashi (1948), Kambara (1953) and others, the spawning season around Hokkaido extends over a three-month period from toward the end of September to December, and there is every indication that the eggs are laid earlier in northern region than in southern region; the period from the middle of September to the middle of October around Shiretoko Peninsula on the Okhotsk Sea side of Hokkaido, the period from the latter part of September to the middle of November around Rishiri Is. and Rebun Is. on the Japan Sea side of Hokkaido and the first decade of November~the same of December in the southern region on the Japan Sea side of Hokkaido are assumed season.

The spawning of "hokke" is found only on the rocks and the gravel zones several tens~hundreds meters out of land with a depth from six to thirty meters. In about one hour after fertilization, the eggs laid out get together in depressions of rocks and among gravels. Number of clumps ranges from four to thirty per "Tsubo" (3.3 m^2.) and number of eggs contained in a clump coincides nearly with that of eggs spawned at a time by a female "hokke" (Hirano, 1947; Hokkaido Fish. Sci. Inst., 1953; Hokkaido Reg. Fish. Res. Lab., 1956. …).

6) **Morphological development of eggs and larvae**

Although artificial fertilization of "hokke" eggs is tried by Hirano (1947), Yuasa (unpublished) and others, but it failed all with hatching. Hirano and Kondo (1948) first succeeded in observations of development within eggs from fertilization till

hatching. According to the results, fertilized eggs, at 7.8°C. of average water temperature, hatch out between 53 and 59 days after artificial fertilization, and total length of larvae just after hatching is 11 mm..*

The body colour of "hokke" larvae takes on greenish blue when body length is less than about 115 mm., at this length irregular brownish yellow spots beginning to appear on the body, and geenish blue hue becomes lighter when body length reaches about 140~150 mm. (Kambara, 1950).

3 Identification of larvae

Family Hexagrammidae, "ainame ka", around Japan contains 8 species (4 genera), of these, 6 species (Taranetz, 1937) or 7 (Matsubara, 1955) are found in the Japan Sea.

A distinctive peculiarity of larvae belonging to family Hexagrammidae takes on greenish blue colour on the dorsal side. The colour is an adaptation to the superficial life at larval stages. The spawning seasons of this family, as far as known, are all found during the period from late autumn to winter (Nakamura, 1936; Oshima and Nakamura, 1944; Hirano, 1947; Yamamoto and Nishioka, 1948; Kambara, 1950; Abe, 1951; 1953. …).

The most remarkable difference between "hokke" larvae and those of other genera belonging to family Hexagrammidae is number of myotomes which coincide nearly with that of vertebra; namely number of vertebra of five species belonging to Hexagrammidae is as follows (Hokkaido Reg. Fish. Res. Lab., 1954).

Japanese name	Scientific name	Number of vertebra
Kujime	*Agrammus agrammus* (Tem. et Schl.)	49
Hokke	*Pleurogrammus azouus* Jordan et Metz	59~63
Ainame	*Hexagrammus otakii* Jordan et Starks	51
Suji-ainame	*H. octogrammus* (Pallas)	50~51
Usagi-ainame	*H. lagocephalus* (Pallas)	54

As shown in table 4 (Hokkaido Reg. Fish. Res. Lab., 1952, 1953), number of vertebra of "hokke" caught around Hokkaido, for the most part, is from 60 to 62. Therefore it may be sure that, of larvae of family Hexagrammidae, which dorsal part takes on peculiar greenish blue colour, larvae with about sixty of myotomes will be "hokke" larvae. On the other hand, "hokke" larvae, to some extent, are more slender in body form than "ainame" larvae and "kujime" larvae. Further differences between "hokke" larva and "ainame" larva & "kujime" larva are as follows.

* There found larvae smaller than 11 mm., namely about 8 mm. in total length in the samples caught by the authors at cruises. Then Tatsuo Yusa, Hokkaido Reg. Fish. Res. Lab., writes the authors the minimum length of artificial hatch tried by him is 8.8 mm. (unpblished).

Table 4 Frequency of vertebral number of atka-fish.

Year	Month	Locality \ No. of Vertebrae	Number of atka-fish by the number of vertebrae						
			58	59	60	61	62	63	64
1952	June～Dec.	Kumaishi, Hokkaido	0	8	88	345	179	14	1
〃	April～May	Tsugaru Strait	1	5	63	324	179	15	0
〃	June～July	Horoizumi, Hokkaido	0	1	95	214	91	12	0
1951	Oct.～Dec.	Okhotsk Sea	0	27	156	316	137	9	0

i) Anus of "hokke" larva is situated more ahead than the others.

ii) Greenish blue colour hue on the flanks, in "hokke" larva, takes on a little faint compared with the others.

iii) Also in larger "hokke" larva, black chromatophore on caudal fin rays can be little recognized.

And genus *Pleurogrammus* Gill contains "kita-no-hokke", *Pleurogrammvs Monopterygius* (Pallas) besides "hokke". Those two species differ each other in number of lateral pits on the 2nd lateral lines, in the ratio of the ventral fin length to the head length, and in number of dorsal fin rays and anal fin rays (Taranetz, 1937).

On the basis of the Taranetz's hierchy, genus *Pleurogrammus* caught around Hokkaido is all regarded as "hokke" (Hirano, 1947). According to Taranetz, "kita-no-hokke" live in the Okhotsk Sea and in the Bering Sea. Matsubara (1955) also reported its existence on the Siberia side of the Japan Sea. *Pleurogrammus* larvae with body length from 5 to 14 cm. caught in the Hidaka district, on the Pacific coast of Hokkaido, during period June～July are all identified by Kambara (1950) as "hokke" larvae; his identification is based upon Taranetz's hierchy.

Larvae of genus *Pleurogrammus*, which are treated in this thetis, collected by "maru-chi" net on the Japan Sea side of northern Honshu and around Hokkaido are all surely *Pleurogrammus azonus* Jordan et Metz, except larvae in the central part of the Japan Sea, on which the authors have not perfectly finished identification.

4 Geographical distribution of larvae and youngs

1) Collecting of materials

On the occurrence of "hokke" larvae, Kaganowsky (1936), Kambara (1950), Abe (1951, 1953) and others reported fragmentarily.

The authors have studied the seasonal and geographical distribution of "hokke" larvae on the basis of samples at 3,762 stations in total, comprising 3,170 samples in total, of which the bulk was identified by one of the authors, H. Fukataki, collected on the Japan Sea side of Honshu during the period from April, 1953 to July, 1956 and 692 samples, identifed by Hokkaido Reg. Fish. Res. Lab. (1955, 1956), collected around Hokkaido during May, 1953～November, 1955.

The occurrence of "hokke" larvae in each month of each year is given in the

appended table, and it is summarized in table 5. of 3,762 samples (stations) in total, at 176 stations 2,547 of "hokke" larvae, ranging from 8 to 161 mm. in total length, are obtained; the period extends from December to July.

However when one studies, on the basis of these results, the monthly change on nursery grounds of "hokke" larva and young, the authors want to call special attention to the following facts.

i) Around Hokkaido assumed as main spawning grounds, judging from the geographical distribution of adult "hokke" catch, the samplings with "maru-chi" net for larvae and eggs are little put into practice in winter season in which the hatching period of "hokke" lies, but in some narrow region of coast.

ii) As the authors have confirmed in the research curise on board the research vessel "Tenyo Maru" in April, 1956, in the central part of the Japan Sea, nursery grounds of "hokke" larva cover a wide area.

To sum up, in the research a vacancy is left behind seasonally and also spatially, and in the very vacancy important season and area that there assumed occurrence of "hokke" larvae are contained. The research to fill the vacancy will be continued firmly in future.

Eggs of "hokke" can not be collected with present horizontal towings of "maru-chi" net at the sea surface, for they sink to the sea bed and get together massively as stated previously.

2) **Monthly occurrence**

December～January :

Samplings around Hokkaido were carried out only in Ishikari Bay-each 5 stations in December, 1954 and in January, 1955. Of these five stations in December, 1954, at three stations 42 "hokke" larvae ranging from 8 to 10 mm. in total length were collected. This occurrence, seaonally, has been the earliest; these are also, judging from their total length, larvae just after hatch. Then from five stations in the same bay in January, 1955, 174 larvae ranging from 9 to 27 mm. in total legth were obtained. No towing in these two months has been conducted on the Okhotsk side and the Pacific side of Hokkaido.

On the Japan Sea side of northern Honshu 42 towing (stations) in total in December from 1953 to 1955, and 23 towings(stations) in total in January from 1954 to 1956 were carried out. But no "hokke" larva was obtained. these towings were all restricted in Toyama Bay, except December, 1954, therefore it should not be jumped at conclusion that "hokke" larvae do not occur in January in the area north from the Bay.

February (figs. 2, 3) :

Around Hokkaido, 5 towings were made in Ishikari Bay in February, 1955; of the 5 stations at 3 stations 41 larvae ranging from 11 to 31 mm. in total length were obtained. No towing was made in any other areas around Hokkaido.

On the Japan Sea side of northern Honshu larvae appear first in February. In February, 1955, 22 larvae in total ranging from 10 to 15 mm. were collected at two stations situated between Nyudo Saki, Akita Pref. and Henashi Saki, Aomori Pref., and in February, 1956, a larva with 10 mm. in total length was obtained off Washi Saki, Sado Is.. These larvae, judging from their total length, are all organisms soon after hatch, and their appearences are about two months overdue compared with them around Ishikari Bay, Hokkaido The southernmost end of geographical distribution, which has been confirmed, in February, lies around Sado Is..

March (figs. 4~6) :

Around Hokkaido, towings were made only at two stations in Ishikari Bay at which 33 larvae ranging from 14 to 22 mm. in total length were obtained.

Geographical distribution of atka-fish larvae in the Japan Sea, during 1953~1956. (figs. 2~15).

○ : the position of the towed station but no larvae were obtained.

● : the position of station, at which larvae were obtained.

Arabic numerals at station : the number of larvae.

" in parenthese : the range of total length of larvae (mm.)

" on land : the towing period in each month.

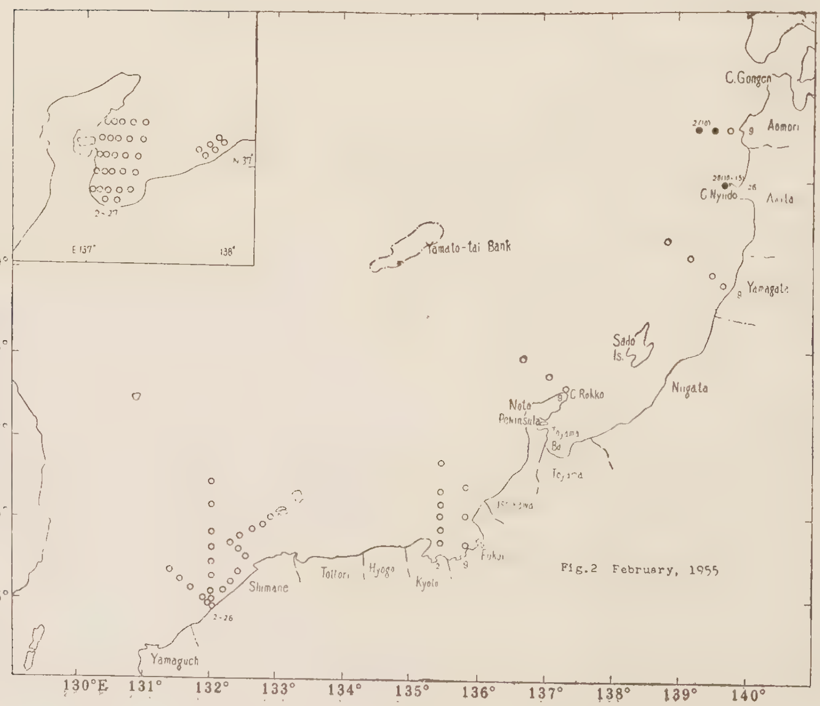


Fig.2 February, 1955

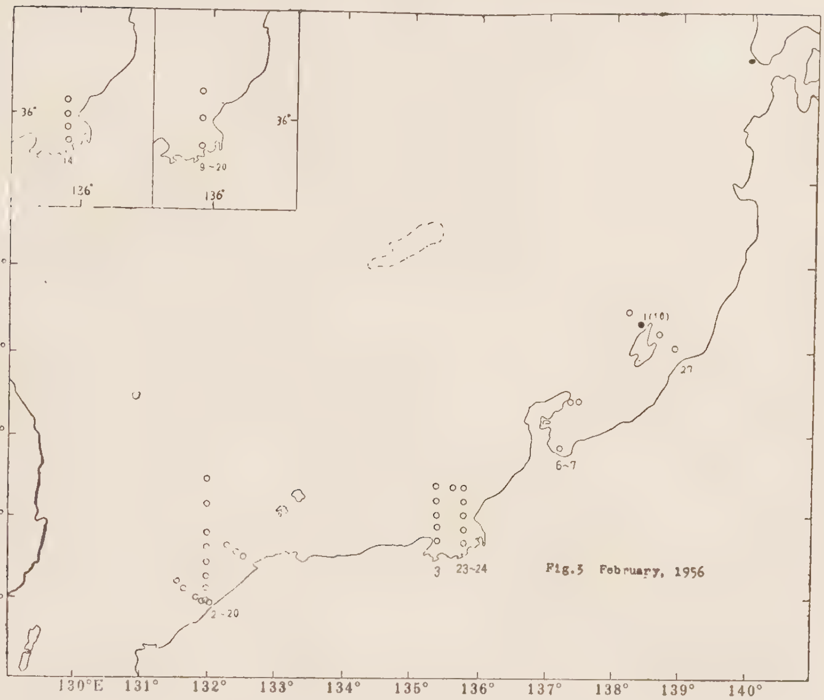

Fig.3 February, 1956
36°
136°
9 ~ 20
39°
38°
37°
36°
35°
1(10)
27
6~7
3
23~24
2 ~ 20
130°E
131°
132°
133°
134°
135°
136°
137°
138°
139°
140°


Fig.4 March, 1954
41°
N
40°
38°
37°
36°
35°
130°E
131°
132°
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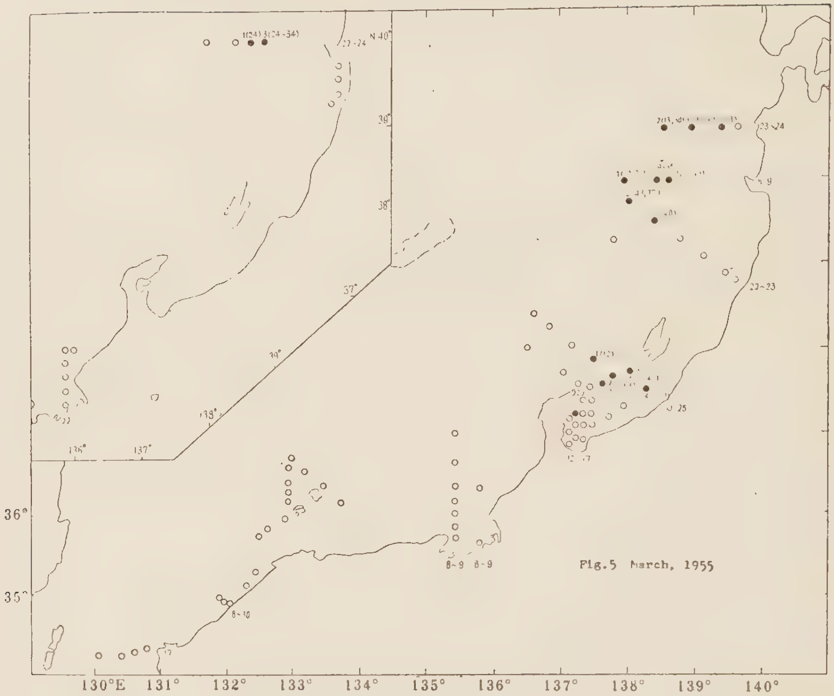


Fig.5 March, 1955

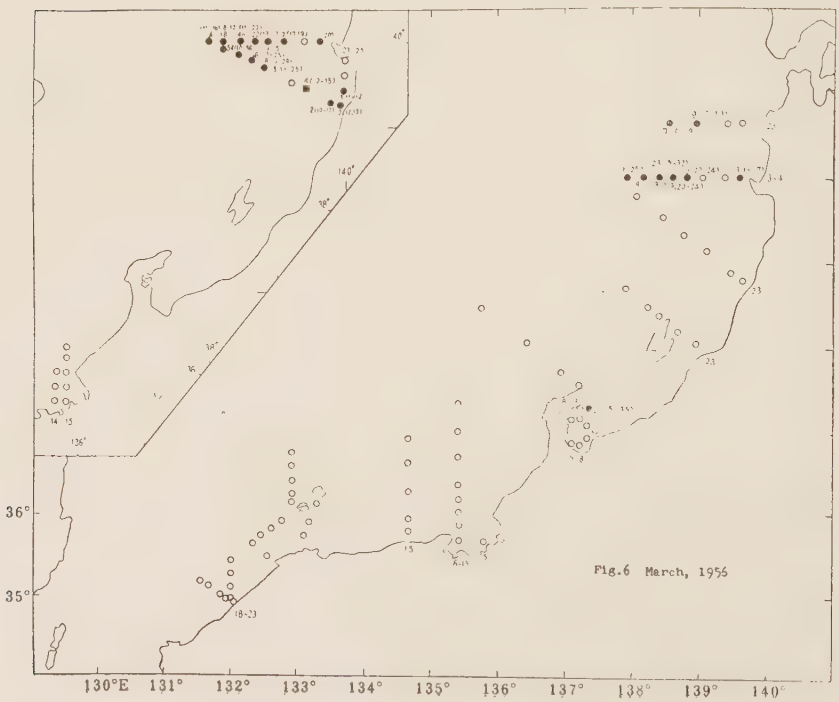


Fig.6 March, 1956

On the Japan Sea side of northern Honshu, towings were made in three years from 1954 to 1956 at total 143 stations of which at 51 stations total 509 larvae ranging from 8 to 74 mm. were collected. The southern-most end of geographical distribution advances south, reaching Toyama Bay, in this month. The good area captured most abundantly is the offing of Akita Pref.. There found "hokke" larvae with 63 mm. and 45 mm. in total length in samples collected by research vessel of Akita Prefectural Fish. Exp. St., the "Senshu Maru" at Yamato Bank region at midnight on March 30, 1950, and at the same time three smaller larvae (26.7 mm., 21.3 mm. and 18.0 mm. in standard length) which are assumed ample hope for "hokke" were also obtained (Abe, 1951). So it is unquestionable that at least toward the end of March, "hokke" larvae, growing to some extent, live even in the central part of the Japan Sea.

April (figs. 7~12) :

Around Hokkaido, towings in April were made at 26 stations around and in Ishikari Bay only in the year 1954; no towing has been carried out in any other areas and years. Of these 26 staions, at 21 stations except 5 placed closely inshore total 453 "hokke" larvae ranging from 17 mm. to 33 mm. in total length were obtained.

On the Japan Sea side of northern Honshu, towings were made at total 213 stations in four years from 1953 to 1956; in each year "hokke" larvae were obtained in fair abundance. In the year 1954 and 1955 samplings were made in relatively

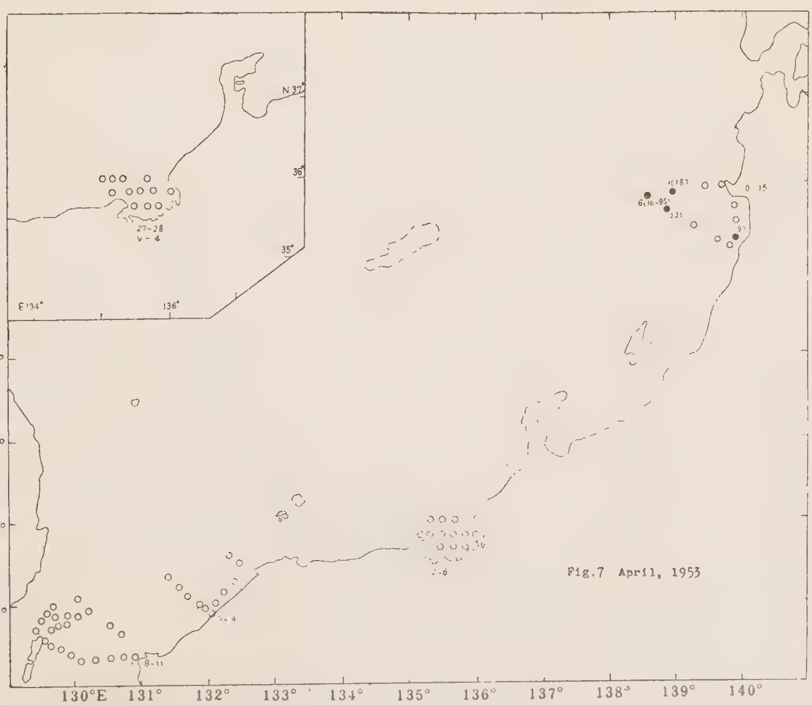


Fig.7 April, 1953

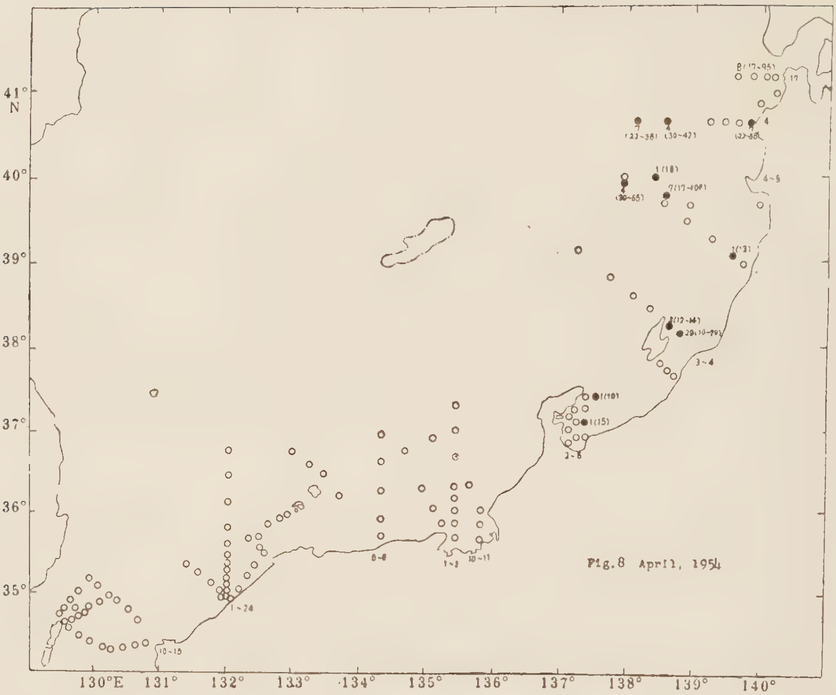


Fig.8 April, 1954

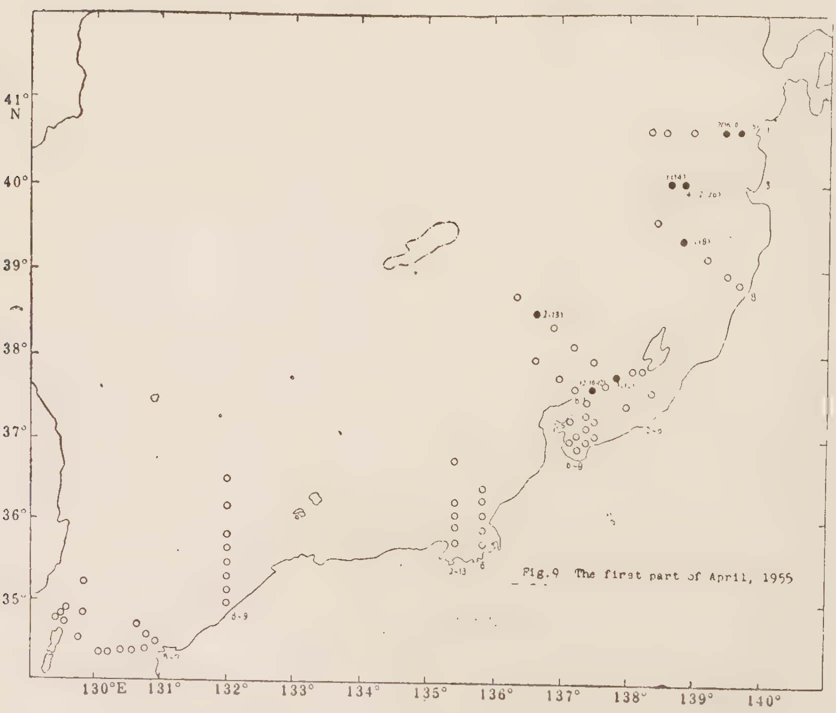


Fig.9 The first part of April, 1955

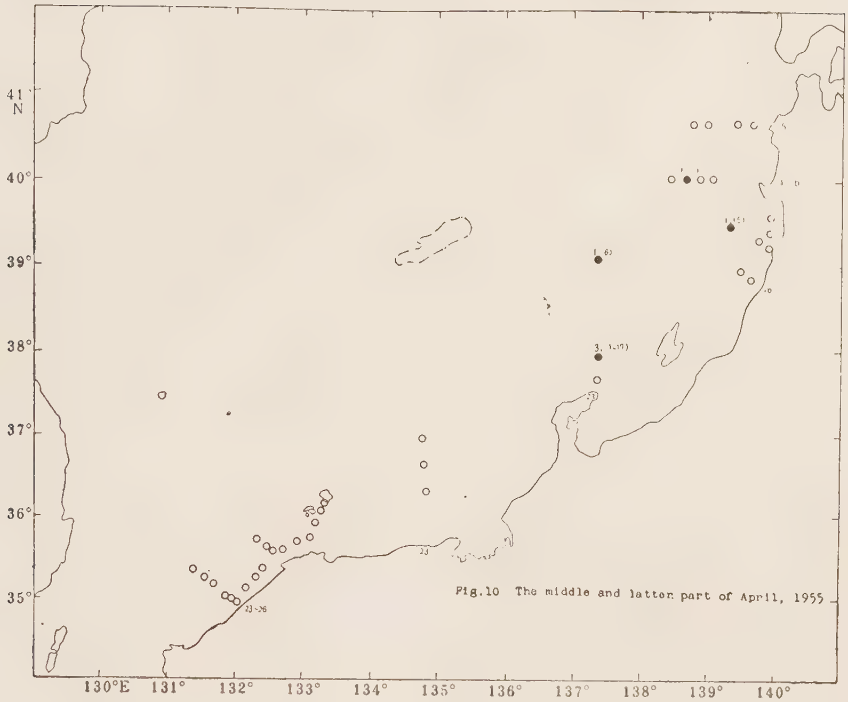


Fig.10 The middle and latter part of April, 1955

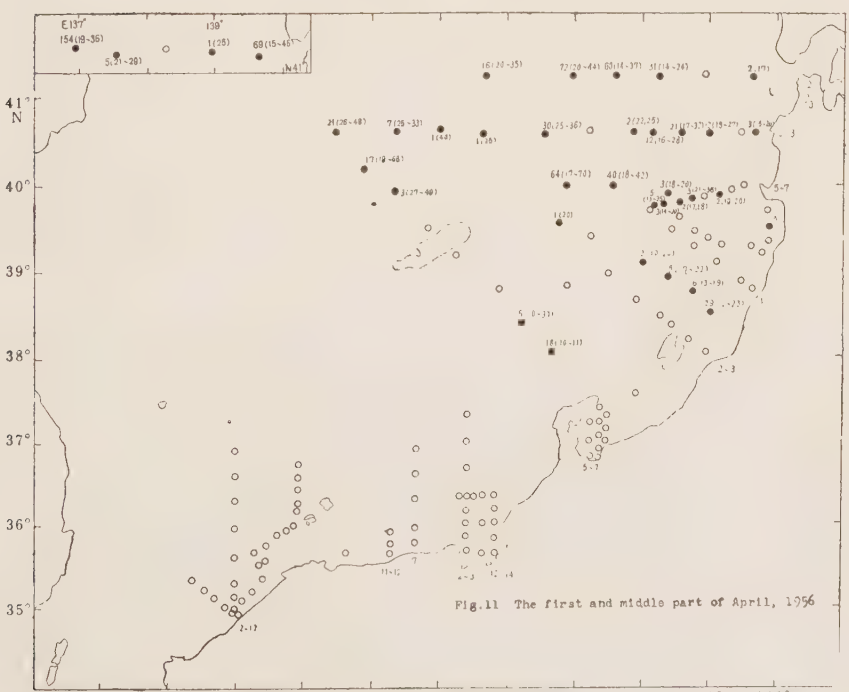


Fig.11 The first and middle part of April, 1956

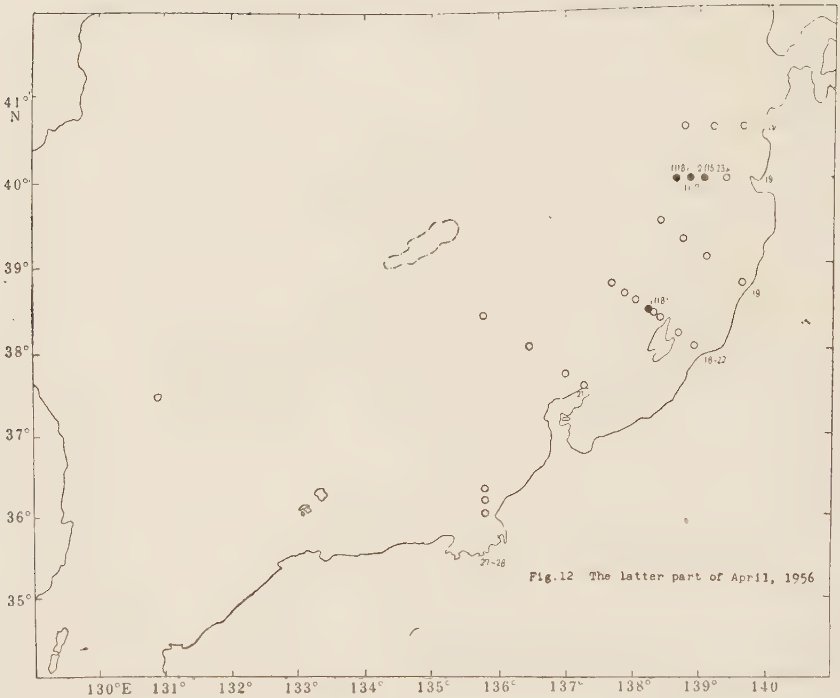


Fig. 12 The latter part of April, 1956

neritic region; comparing April with March in these years, both number of stations at which larvae were obtained and of larvae obtained show a tendency to decrease in April. However the authors have confirmed on board the research vessel "Tenyo Maru" in April, 1956 that relatively large "hokke" larvae live in fair abundance also in the central part of the Japan Sea. On the research cruise, towings were made at 35 stations. Of these 35 stations, at 25 stations total 662 "hokke" larvae ranging from 10 to 77 mm. in total length were obtained. In table 5, consequently, number of larvae in April is seemingly larger than in March.

May (figs. 13～15):

Around Hokkaido, towings were made only on the Japan Sea side, being made at 18 stations covering sea area from Shakotan Peninsula to Rishiri Is. during the period May 7～12, 1953. Of the 18 stations, at 8 stations 331 of relatively large larvae ranging from 27 to 119 mm. in total length were collected. This is the last occurrence season on the Japan Sea side of Hokkaido. No larva was obtained by towings made, both late in May, 1953, in area extending from Shakotan Peninsula to the western entrance to the Tsugaru Strait and in May, 1954, around the western entrance to the same strait.

On the Japan Sea side of northern Honshu, towings were made in every year of 1953～1956. But no larva was obtained in May, 1953; a small number of larvae in the

Table 5 Occurence of atka-fish, by month and region, in tows made during June, 1953 ～ November, 1955 (Hokkaido) and during April, 1953～July, 1956 (Honshu).

Region	Japan Sea side of Honshu						Surrounding waters of Hokkaido									
Sub-region	Northern region (north of Ishikawa Pref.)				Western region (west of Fukui Pref.)		Japan Sea side				Okhotsk Sea side				Pacific side	
Month	A No. of total sts., at which towings were made.	B No. of sts., at which larvae were obtained.	C No. of larvae	D Range of total length	A	B	A	B	C	D	A	B	C	D	A	B
				mm.						mm.				mm.		
Total	1,288	130	1,427	8～100	1,885	0	538	42	1,075	8～119	148	4	45	23～161	31	0
Jan.	23	0	0		92	0	5	5	174	9～27	0	0	0		0	0
Feb.	93	3	23	10～15	134	0	5	3	41	11～31	0	0	0		0	0
March	146	51	509	8～74	137	0	2	2	33	14～22	0	0	0		0	0
April	213	69	847	9～100	250	0	26	21	453	17～33	0	0	0		0	0
May	200	7	48	15～71	262	0	46	8	331	27～119	0	0	0		0	0
June	167	0	0		211	0	181	0	0		15	2	40	23～68	0	0
July	169	0	0		177	0	101	0	0		73	2	5	136～161	0	0
Aug.	54	0	0		189	0	104	0	0		35	0	0		21	0
Sept.	70	0	0		114	0	18	0	0		4	0	0		10	0
Oct.	60	0	0		139	0	36	0	0		21	0	0		0	0
Nov.	49	0	0		96	0	9	0	0		0	0	0		0	0
Dec.	44	0	0		84	0	5	3	42		0	0	0		0	0

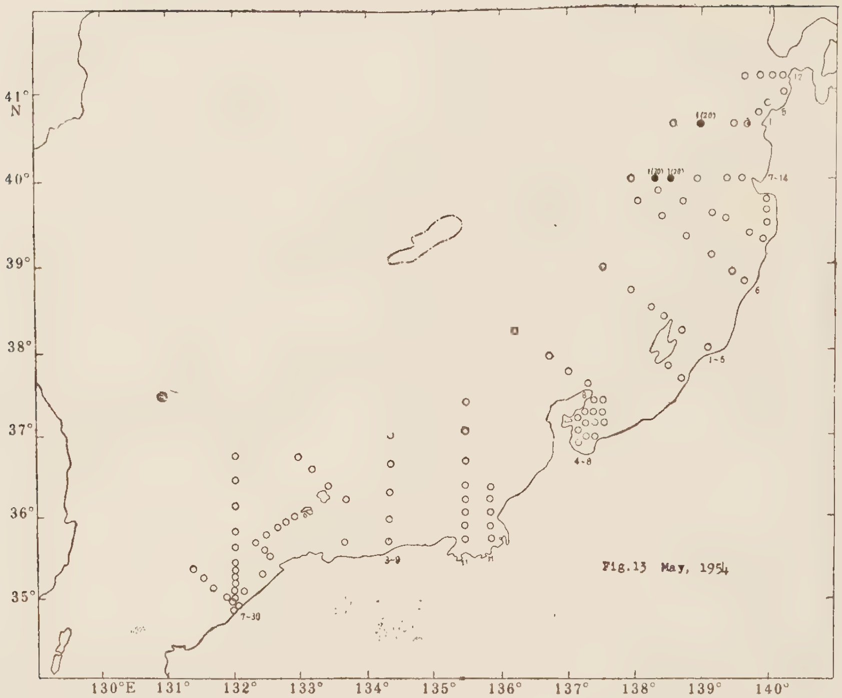


Fig.13 May, 1954

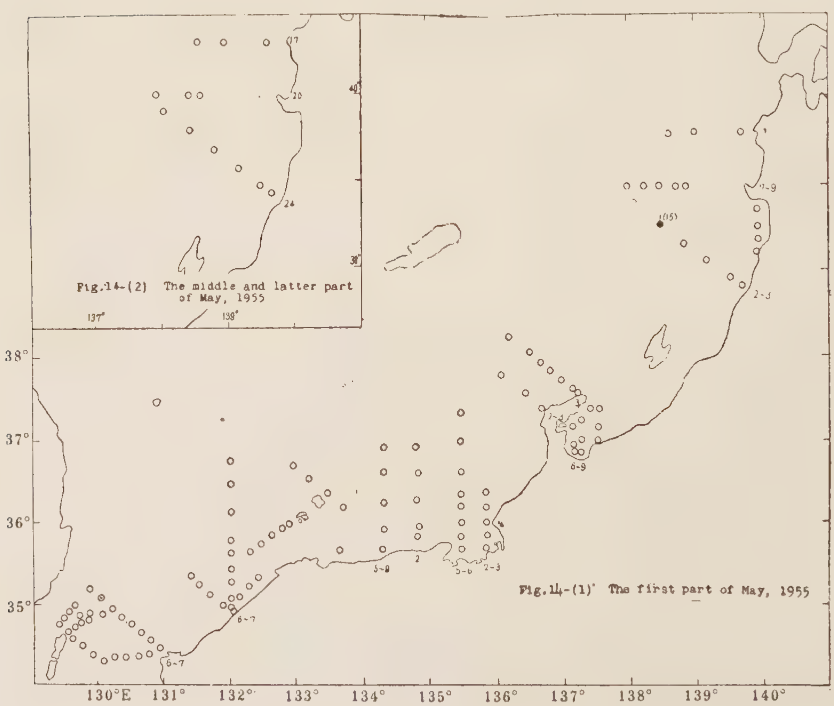


Fig.14-(2) The middle and latter part of May, 1955

Fig.14-(1) The first part of May, 1955

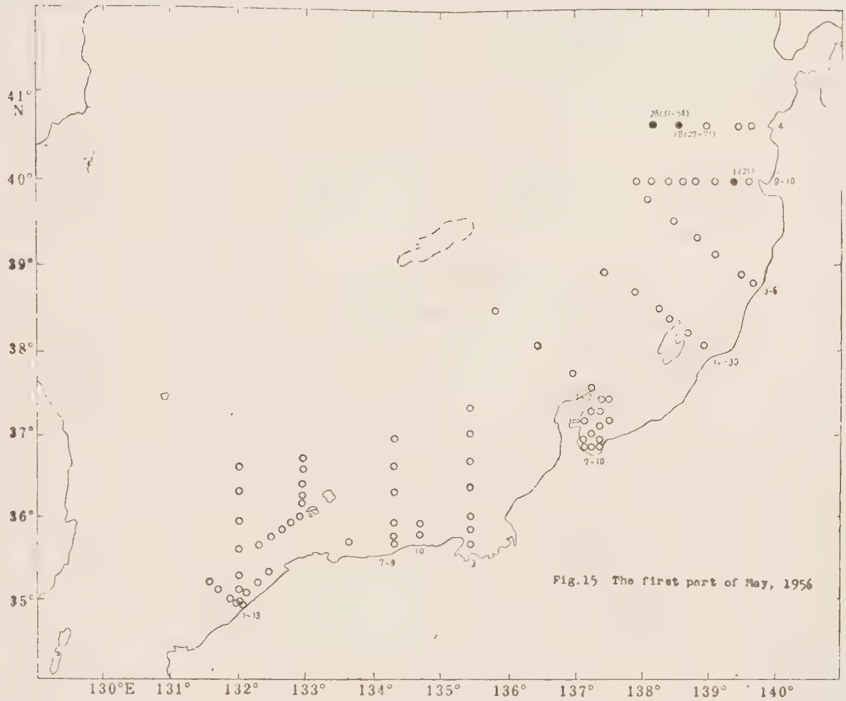


Fig. 15 The first part of May, 1956

same month in 1954 and 1955 ; a number of large larvae ranging from 27 to 71 mm. in total length off Henashi Saki, Aomori Pref in 1956. Always in three years 1954~1956, the southern most end of occurrence is situated in the offing of Akita Pref., and the distribution area moves to off region of low water temperature.

On the other hand even in May, some larvae live in neritic regions; in the Okhotsk Sea, on the east coast of Aniva Bay, Saghalien, larvae with 60 mm. in standard length was found (Abe, 1951); in the Japan Sea, three larvae (95 mm.~115 mm. in body length) were obtained in settle nets on the southern coast of the Japan Sea side of Hokkaido (Hokkaido Fish. Sci. Inst., 1953); on the Pacific side, "hokke" larvae with about 100 mm. in total length were obtained, late in May, in small settle nets on the coast of Sanriku district (Abe, 1953).

June~July :

In the two months, research was conducted over considerably extensive area covring the Japan Sea side of Hokkaido and also of northern Honshu, none the less no larva was obtained.

On the other hand, in the Okhotsk Sea "maru-chi" net was towed at 15 stations in June, 1954, and 40 of larvae ranging from 23 mm. to 68 mm. in total length were caught; in July, 1954, towings were made at 32 stations, and in July, 1955 at 41 stations and total 5 larvae ranging from 136 mm. to 161 mm. in total length were obtained which were collected at one station, respectively. In 1955, on a cruise to

Kamchatka and back, larvae with the same size were caught north off central the Kuril Islands by spoon-net, using light at night.

On the Pacific side of Hokkaido, there are no towing in June and also in July.

In the very months when larvae by "maru-chi" net are almost gone, relatively large larvae are caught, very often, in small settle nets, in the northern sea. For example, on the 23rd of July, larvae ranging from 85 mm. to 95 mm. in total length were caught around Askold Is. in Peter the Great Bay (Kaganowsky, 1936); on the 18 th of June, 108 of larvae ranging from 145 mm. to 185 mm. in body length were caught on the coast of Rishiri Is., Hokkaido (Hokkaido Fish. Sci. Inst., 1953); on the 4 th of June, a larva with 165 mm. in the Tsugaru Strait and on the 21 st of July, 21 of larvae ranging from 93 mm. to 117 mm. in body length were obtained aronud Kushiro (Hokkaido Fish. Sci. Inst., 1953); in Hidaka district on the Pacific side of Hokkaido, larvae ranging from 100 mm. to 150 mm. in body length were caught early in July, and larvae 130 mm.～160 mm. late in July, all in small settle nets (Kambara, 1950); during the period June～July, many larvae ranging from 100 mm. to 120 mm. were obtained in Aniva Bay, Saghalien (Abe, 1951); in Sanriku district, larvae with 100 mm. or so were caught in settle nets, till early in June (Abe, 1953).

August～November :

During the period August～November any larva was not obtained at all in towings of "maru-chi" net, throughout all the seas under investigation. Also in settle nets, larvae were scarcely obtained during this season. From August on, "hokke" more than 150 mm. in body length were caught in one boat small trawl nets on rare occasions, and after October, young "hokke" over 180 mm. were caught in abundance, on the Okhotsk Sea side and on the Japan Sea side of Hokkaido (Hokkaido Reg. Fish. Res. Lab., 1956).

3) **Regional occurrence**

As shown in table 5, in the Japan Sea no "hokke" larva has been obtained in Fukui Pref. and westward. Consequently, the southernmost end of appearence of "hokke" larvae is assumed to be situated around Noto Peninsula. On the Pacific side, it lies around Kinkazan, Miyagi Pref. as reported by Abe (1953). These southernmost end of larvae occurrence coincides well with those of commercial landing of "hokke" fishing shown in figure 1.

The most off occurrence in the Japan Sea, so far as confirmed by the authors on board, is situated in latitude 40°36′N., longitude 133°27′E. (fig. 11). But there is an ample hope for occurrence of "hokke" larvae in the more northern area, to the Siberia. Considering in connection with report of Kaganowsky (1936), in the period of larval stage of "hokke", the distribution area of larvae spawned on the Siberia coast and that on the Honshu coast of the Japan Sea seem to be overlapped partially at least. Consequently, the larvae in different birthplaces will partially

mix together. Migration, which confirmed by tagging experiments, of immature and adult "hokke" living a bottom life, was confined within relatively narrow limits (Hokkaido Reg. Fish. Res. Lab., 1956; Abe and Ichikawa, 1952); matured "hokke" do not migrate widely (Sano, 1956). Namely the wide distribution in larval stage makes a remarkable contrast to the confined distribution in bottom life stage.

The northern-most end of "hokke" larvae has not yet been confirmed.

5 Main spawning grounds and seasons

Judging from the geographical distribution of "hokke" catch (fig. 1 and table 1) and the body length range of its catch (fig. 16), it is clear that the bulk of adult "hokke" is caught on the Japan Sea side of Hokkaido. Therefore the sea area will be the main spawning ground of "hokke".

As shown in table 8, number of larvae caught during the period from December to February on the Japan Sea side of Hokkaido is larger compared with number of larvae at the same time by day in other sea regions and that at the same time by day during the period from March to May on the Japan Sea side of Hokkaido (although night towings of "maru-chi" net has not been made at all, more larvae will be expected by night). Consequently, when it takes two months for eggs to hatch out, on the Japan Sea side of Hokkaido, the period from October to Decmber is assumed the main spawning season.

6 Relation between the occurrence of larvae and the sea conditions

Good fishing ground of "hokke" in the Okhotsk Sea is formed within the range from 2° to 4°C. especially 3°～4°C. at 70～100-merer layer (Tomabeti, 1952). Around Rishiri Is., Hokkaido, adult "hokke" begin to visit the neritic waters to feed on, when surface water temperature rises to 5°C. or so in spring, and the fishing season continue till in June when surface water temperature rises to about 10°～12°C. (Tamura and Okubo, 1952).

Surface water temperature when young "hokke" are caught in settle nets in the neritic regions on the Pacific side of Hokkaido lies within the range from 8° to 14°C. (Kambara, 1950).

In table 6, the occurrence of larvae sampled with "maru-chi" net are shown by the surface water temperature range and by the sea area.

All stations towed during the period from February to May, when "hokke" larvae appear on the Japan Sea side of northern Honshu, range from 2° to 18°C. at 0-meter layer of the sea, and larvae are obtained only within the range from 2° to 12°C.; number (percentage) of stations at which larvae were obtained and of larvae per towing are larger in low water temperature region below 6°C. level, especially larvae are obtained at all stations at which towings were made within the

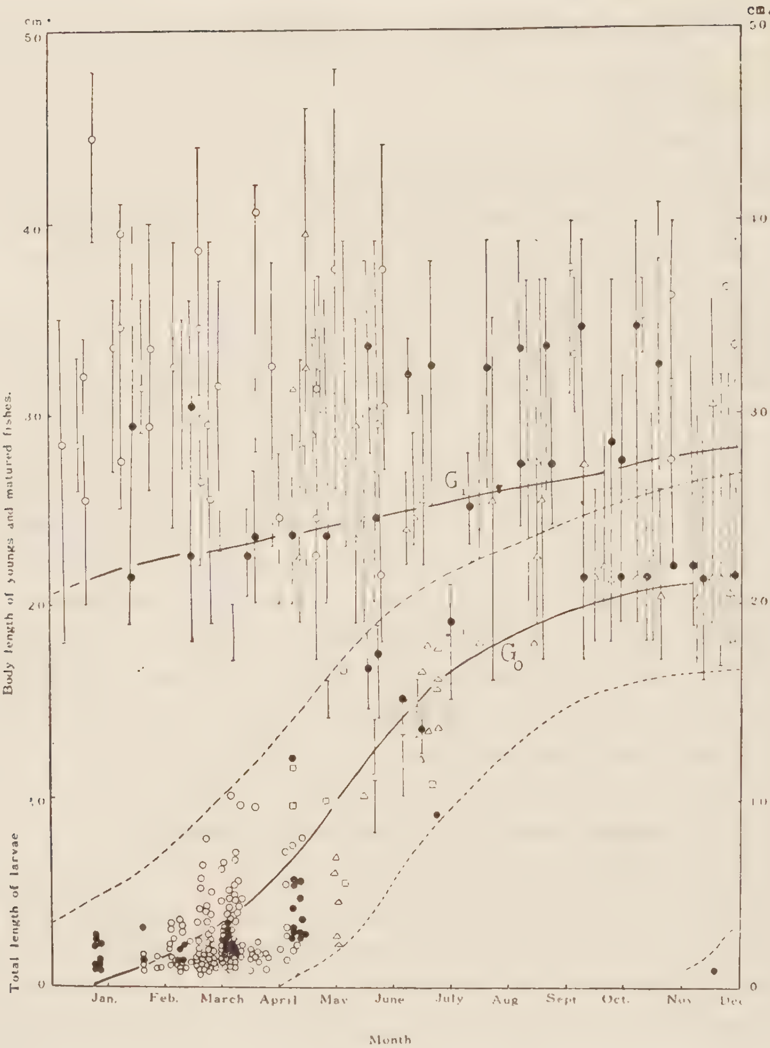


Fig. 16 The range and modal size of larvae, youngs and matured fishes of atka-fish.

The following symbols designate the sea area.

○ : Japan Ses side of northern Honshu.

● : Japan Sea side of Hokkaido

△ : Okhotsk side of Hokkaido.

□ : Pacific side of northern Honshu & Hokkaido.

|—●—| etc : Range with mode.

○. ●. △. □ : Individual value.

range 5.0°~6.9°C.. Although the minimum surface temperature of all towed stations lies on 2°C. level, it is suspected that larvae live also below 2°C.. In the area over 7°C., the percentage of stations, at which larvae were caught, in total stations, at which towings were made, and number of larvae per towing decreases remarkably;

Table 6 Relation between the occurrence of atka-fish larvae and surface water temperature.

Region / Period / Item	Japan Sea side of Honshu							Surrounding waters of Hokkaido															
								Japan Sea side							Okhotsk Sea side							Pacific side	
	February～May					June～January		December～May					June～Nov		June～July					August～October		August～Sept.	
Surface temperature range (°C.)	A No. of total sts., at which towings were made	B No. of sts., at which larvae were obtained.	C No. of larvae	B/A (%)	C/A	A	B	A	B	C	B/A (%)	C/A	A	B	A	B	C	B/A (%)	C/A	A	B	A	B
2.0～2.9	5	4	273	80.0	54.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.0～3.9	5	4	107	80.0	21.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0～4.9	4	2	9	50.0	2.2	0	0	11	11	401	100.0	37.2	0	0	0	0	0	0	0	0	0	0	0
5.0～5.9	10	10	141	100.0	14.1	0	0	4	3	13	75.0	3.2	0	0	0	0	0	0	0	0	0	0	0
6.0～6.9	5	5	102	100.0	20.4	0	0	11	9	136	81.5	12.4	0	0	1	0	0	0	0	0	0	0	0
7.0～7.9	16	11	95	68.7	5.9	0	0	5	3	53	60.0	10.6	0	0	0	0	0	0	0	0	0	0	0
8.0～8.9	72	35	374	48.6	5.2	0	0	8	3	182	37.5	22.7	1	0	0	0	0	0	0	0	0	0	0
9.0～9.9	116	31	242	26.7	2.1	0	0	5	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0
10.0～10.9	134	19	73	14.5	0.5	3	0	3	0	0	0	0	19	0	11	0	0	0	0	1	0	0	0
11.0～11.9	128	8	10	6.2	0.0	0	0	5	0	0	0	0	27	0	12	1	1	8.3	0.1	0	0	0	0
12.0～12.9	35	1	1	2.8	0.0	22	0	2	0	0	0	0	24	0	5	0	0	0	0	0	0	1	0
13.0～13.9	57	0	0	0	0	5	0	5	0	0	0	0	34	0	0	0	0	0	0	2	0	2	0
14.0～14.9	31	0	0	0	0	17	0	0	0	0	0	0	37	0	0	0	0	0	0	1	0	2	0
15.0～19.9	12	0	0	0	0	306	0	0	0	0	0	0	152	0	0	0	0	0	0	14	0	20	0
20.0～24.9	0	0	0	0	0	189	0	0	0	0	0	0	97	0	0	0	0	0	0	0	0	6	0
25.0～28.9	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
unknown	22	0	0	0	0	14	0	30	0	0	0	0	54	0	56	3	44	5.3	0.7	42	0	0	0
Total	652	130	1,427	20.0	2.2	636	0	89	42	1,075	47.2	12.0	449	0	88	4	45	4.5	0.5	60	0	31	0

then in the area over 13°C. no larva was obtained. Surface temperatures at all stations, at which towings have been made, range from 10° to 28.9°C. during from June to January, when no larva was obtaind; namely they are higher than those during from February to May, and number of stations below 12°C., the upper limit of occurrence of larvae, at which towings were made, is only below 4 per cent of total stations.

In the period December to May, the occurrence season of "hokke" larvae on the Japan Sea side of Hokkaido, surface water temperature at all stations at which towings were made range from 4° to 13.9°C., and of these, catch of larvae is limited within the range from 4° to 8.9°C. at the sea surface. No towing has been made in the low water temperature regions below 3.9°C., for towings are made only in limited areas. But it is assumed, judging from the sea conditions on the Japan Sea side of northern Honshu, that larvae will live also in lower temperature regions than 3.9°C.. The maximum temperature of occurrence on the Japan Sea side of Hokkaido is lower than that on the same side of Honshu. Surface temperature at all stations, at which towings have been made, range from 8° to 24.9°C. during the period from June to November; namely both the lower and upper limits of water temperature considerably rise compared with that during from December to May.

No towing has been made before May, when it is assumed that the main season of occurrence on the Okhotsk Sea side of Hokkaido lies. And then, as temperature has been scarecely taken at many stations, in June and in July, the details on larvae occurrence are furthermore to be studied. But larvae have been obtained in the waters of 11°C. level. The surface water temperature during the period from August to October, when no larva occured on the Okhotsk Sea side of Hokkaido, range from 10° to 19°C..

Towings on the Pacific side of Hokkaido have been made only in August and September, and the surface water temperature in the season range from 12° to 23°C., but no larva has been obtained.

As mentioned above, "hokke" larvae occur below 12°C. of surface temperature, especially abundantly below 7°C.. In the dropping season of water temperature just after the hatching season, the southernmost end of occurrence in the Japan Sea lies around Noto Peninsula, and it goes up north with the rise of surface temperature. Then larvae disappear perfectly, in the Japan Sea, from June onward, being confined to the northern seas like the Okhotsk Sea. On the other hand, "hokke" change in ecological behaviors with their growth (see the next clause "Diurnal migration"). Therefore, it is estimated that no larva becomes obtained in "maru-chi" net, as habitat of "hokke" remove vertically to deeper layers or the sea beds, at the same time as the condensation of horizontal distribution region toward the north.

The range of surface chlorinity in the occurrence region of larvae is given in table 7.

Table 7 Relation between the occurrence of atka-fish larvae and surface water chlorinity.

Region	Japan Sea side of Honshu							Surrounding waters of Hokkaido															
								Japan Sea side							Okhotsk Sea side							Pacific side	
Period	February~May					June~January		December~May					June~Nov.		June~July					August~October		August~Sept.	
Item / Surface chlorinity range (‰)	A No. of total sts., at which towings were made	B No. of sts., at which larvae were obtained.	C No. of larvae	B/A (%)	C/A	A	B	A	B	C	B/A (%)	C/A	A	B	A	B	C	B/A (%)	C/A	A	B	A	B
11.0~11.9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.0~12.9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.0~13.9	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0~14.9	2	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0~15.9	2	0	0	0	0	7	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
16.0~16.9	11	0	0	0	0	11	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
17.0~17.7	35	0	0	0	0	36	0	0	0	0	0	0	8	0	0	0	0	0	0	7	0	0	0
17.8	14	1	2	7.1	0.1	10	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	1	0
17.9	13	0	0	0	0	11	0	0	0	0	0	0	4	0	13	0	0	0	0	0	0	0	0
18.0	12	1	1	8.3	0.1	14	0	1	0	0	0	0	3	0	2	0	0	0	0	1	0	0	0
.1	6	0	0	0	0	16	0	1	0	0	0	0	6	0	2	0	0	0	0	0	0	4	0
.2	14	4	37	28.6	2.6	27	0	2	0	0	0	0	8	0	1	0	0	0	0	1	0	5	0
.3	12	3	4	25.5	0.3	29	0	1	0	0	0	0	16	0	0	0	0	0	0	2	0	4	0
.4	15	1	5	6.7	0.3	51	0	1	0	0	0	0	11	0	0	0	0	0	0	0	0	2	0
.5	30	1	1	3.3	0.0	55	0	0	0	0	0	0	37	0	1	0	0	0	0	0	0	1	0
.6	33	3	10	9.1	0.3	69	0	1	0	0	0	0	56	0	3	0	0	0	0	0	0	5	0
.7	78	18	94	23.1	1.2	74	0	6	2	30	33.4	5.0	91	0	5	1	1	20.0	0.2	2	0	6	0
.8	169	73	1,079	43.2	6.4	81	0	46	[illegible]	755	55.6	16.4	129	0	1	0	0	0	0	5	0	3	0
.9	74	18	127	24.4	1.7	64	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0
19.0	21	1	52	4.8	2.5	30	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
.1	3	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.2	9	3	9	33.3	1.0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown	91	3	6	0	0	33	0	30	13	290	43.3	9.7	54	0	56	3	44	5.4	0.8	42	0	0	0
Total	652	130	1,427	20.0	2.2	636	0	89	42	1075	47.2	12.0	449	0	88	4	45	4.5	0.5	60	0	31	0

On the Japan Sea side of northern Honshu, larvae are obtained in the regions over 17.8 ‰ (surface chlorinity, and so forth), but not perfectly in the neritic regions where the sea waters are extremely diluted by direct inflows of the rivers. The highest percentage of number of stations, at which larvae were obtained, in number of total stations, at which towings were made, and largest number of larvae are found on 18.8 ‰ level. But relatively high percentage of number of stations is found also within the range from 18.2 to 18.3 ‰ level; namely, the region of this relativaly high rate is the mixing area of oceanic waters with neritic waters to give the latest instance, it applies to the area from Awashima Is., Niigata Pref. to Nyudo Saki, Akite Pref. in April, 1956.

As quantitative analysis has been scarecely made around Hokkaido, the details on relation between occurrence of larvae and chlorinity of the sea water are futhermore to be studied. But larvae have been obtained only within the range from 18.7 to 18.8 ‰ level.

7 Diurnal migration of larvae

Occurrence of larvae by time, when towings were made, and by area are arranged in table 8.

On the Japan Sea side of northern Honshu, from the percentage of number of stations, by time, at which larvae were obtained, during the occurrence period (February~May) of larvae, and unmber of larvae per towing, larvae tends to be obtained more abundantly by night than by day.

The occurrence season of larvae on the Japan Sea side of Hokkaido extends from December to May, but during the period from December to February no night towing is made. However in daytime towings during the latter period, as the percentage of number of stations, at which larvae were obtained, is higher and number of larvae per towing is larger, the catch of more abundant larvae is expected in the night towings during the period from December to February. Those conditions during March to May in the same region show the same trend as on the Japan Sea side of northern Honshu, but the ratio of number of stations, at which larvae were obtained, to number of total stations, at which towings were made, and number of larvae per towing are more large than those on the Japan Sea side of northern Honshu.

In the Okhotsk Sea, no towing has been made except midnight.

Judging from the above conditions of occurrence by time, it is estimated that "hokke" larvae take diurnal migration, swimming up to the sea surface by night and down to the deeper layers by day.

Diurnal migration of "hokke" seems to change with their growth and with increase in the sphere of swimming. From table 9 the following three points are lead out.

Table 8 Occurrence of atka-fish by time.

Region	Japan Sea side of Honshu					Surrounding waters of Hokkaido														
						Japan Sea side										Okhotsk Sea side				
Period	February～May					December～February					March～May					June～July				
Item / Time range	A No. of total sts. at which towings were made	B No. of sts. at which larvae were obtained.	C No. of larvae	B/A (%)	C/A	A	B	C	B/A (%)	C/A	A	B	C	B/A (%)	C/A	A	B	C	B/A (%)	C/A
00:00—01:59	30	11	100	36.6	3.3	0	0	0	0	0	6	4	104	66.7	17.3	3	3	13	100.0	4.3
02:00—03:59	26	13	410	50.0	15.8	0	0	0	0	0	3	3	56	100.0	18.6	5	0	0	0	0
04:00—05:59	21	6	83	28.6	3.9	0	0	0	0	0	7	1	5	14.2	0.7	8	0	0	0	0
06:00—07:59	50	10	50	20.0	1.0	0	0	0	0	0	4	2	2	50.0	0.5	9	0	0	0	0
08:00—09:59	81	6	9	7.4	0.1	0	0	0	0	0	8	2	23	25.0	2.8	9	0	0	0	0
10:00—11:59	106	8	23	7.5	0.2	3	2	83	66.6	27.3	6	2	10	33.3	1.6	7	0	0	0	0
12:00—13:59	79	2	3	2.5	0.0	6	4	29	66.6	4.8	7	2	12	28.5	1.7	10	0	0	0	0
14:00—15:59	78	5	9	6.4	0.1	4	3	106	75.0	26.5	5	1	11	20.0	2.2	10	0	0	0	0
16:00—17:59	47	8	13	17.0	0.3	2	2	39	100.0	19.5	9	2	57	22.2	6.3	10	0	0	0	0
18:00—19:59	55	22	233	40.0	4.2	0	0	0	0	0	7	3	39	42.8	5.5	7	0	0	0	0
20:00—21:59	42	19	213	45.2	5.1	0	0	0	0	0	7	4	211	57.1	30.1	4	0	0	0	0
22:00—23:59	37	20	281	54.1	7.6	0	0	0	0	0	5	5	288	100.0	57.6	5	1	32	20.0	6.4
Total	652	130	1,427	20.0	2.2	15	11	257	73.3	17.1	74	31	818	42.0	11.0	88	4	45	4.5	0.5

Table 9 Occurrence of atka-fish larvae by time and total length.

Time	No. of stations, at which larvae were obtained	No. of sts., at which larvae under 30mm. were obtained.	No. of sts., at which larvae over 30mm. were obtained.	No. of sts., at which larvae over 50mm. were obtained.	No. of sts., at which larvae over 100mm. were obtained.
00～	9	5	4	2	1
01～	9	4	5	3	2
02～	6	1	5	1	0
03～	10	4	6	0	0
04～	3	3	0	0	0
05～	4	4	0	0	0
06～	7	6	1	0	0
07～	5	4	1	0	0
08～	4	4	0	0	0
09～	4	4	0	0	0
10～	5	5	0	0	0
11～	7	6	1	0	0
12～	3	3	0	0	0
13～	5	5	0	0	0
14～	5	5	0	0	0
15～	4	4	0	0	0
16～	8	7	1	0	0
17～	4	4	0	0	0
18～	13	10	3	1	0
19～	12	6	6	1	0
20～	11	6	5	2	1
21～	12	8	4	2	0
22～	10	6	4	3	0
23～	16	9	7	4	0

i) Larvae smaller than 30 mm. in total length are caught by day and by night.

ii) Larvae larger than 30 mm. in total length are little obtained by day.

iii) Larvae larger than 50 mm. in total length are obtained only at night (18:00～03:00).

As stated previously, towings, in April, 1956, were made by the authors at 34 stations (16 stations by day and 18 by night) in the central part of the Japan Sea. Of these, number of stations at which larvae were collected is 18 (50% of number of total stations at which towings were made) by day and 17 (94 %) by night; number of larvae per towing is 1.2 by day as against 35.4 by night. The length composition of all larvae obtained on the research cruise is shown in table 10. The mode of total length range from 20 to 29 mm. both by bay and by night. But the majority of larvae range from 15 to 30 mm. by day as against 10～70 mm. by night, including small larvae soon after hatch and larger which are little obtained by day.

The fact that larvae were caught only at midnight, in the Okhotsk Sea (table 8),

Table 10 Occurrence of atka-fish larvae by day and night, in the northern Japan Sea, April 1956. ("Tenyo-maru.")

Time	A No. of total sts., at which towings were made	B No. of sts., at which larvae were obtained.	C Total	10~14 mm.	15~19 mm.	20~24 mm.	25~29 mm.	30~34 mm.	35~39 mm.	40~44 mm.	45~49 mm.	50~54 mm.	55~59 mm.	60~64 mm.	65~69 mm.	70~74 mm.	B/A (%)	C/A
06:00—15:59	16	8	20		3	7	8	1		1							50	1.2
16:00—05:59	18	17	636	42	84	234	178	69	14	5	5	2	1		1	1	94	35.4

is convinced of the reason that towings in the Okhotsk Sea were confined to from June and onward, when larvae grow in considerable grade and are able to migrate pretty well.

To sum up, "hokke" larvae have ability of weak "dirunal migration" just after hatch, and with growth their migrating to the sea surface become confined to night alone. Then the habitat gradually moves from the sea surface to the deeper layers, and at least to the sea bed, reaching 20 cm. and over in total length. With such ecological adaptations, the colour of body changes gradually from greenish blue to brown. As one of the causes that bring about such a diurnal migration is assumed the biological circumtances. For instance, larvae with about 6 cm. feed mainly on *Metridia lucens* (Copepoda), and larger larvae caught in settle nets in neritic waters contain mainly *Calanus cristatus* (Copepoda) in their stomachs (Sano, 1956). On the other hand, *Metridia lucens* is well known as a zooplankton of remarkable diurnal migration (Esterly, 1912).

8 Growth of larvae

An attempt to estimate the growth of "hokke" has been made on the basis of ring patterns of scale, otolith and clavicle (Belchouk, 1938; Hirano and Takahashi, 1943; Hokkaido Fish. Sci. Inst., 1956; Kyushin, unpublished). As given in table 11, the pre-1953 studies greatly varies each other. Consequently there impressed as if age-determination of "hokke" were desperate. The most important cause of such a discord is due to the obscurity of rings on scale* and otolith and to the diversity of interpretations.

Of late years, the study circle for bottom fish of Hokkaido Reg. Fish. Res. Lab. has concluded that a scale is better for reading of number of rings than otolith; through prudent studies the following better results are obtained (Hokkaido Reg. Fish. Res. Lab., 1955, 1956).

i) There are two different groups — in one

Table 11　Records in the past on the atka-fish growth

Researcher	Belchouch		Hirano & Takahashi			Meguro*		Ishigaki*	
Locality of collection	The Japan Sea		Rishiri Is., Hokkaido			Hokkaido(?)		Surrcunding waters of Hokkaido	
Season of collection	September		May						
Position used in reading rings	Scale & clavicle		Scale			Scale		Otolith	
Number of examined fishes	54		40			348		448	
Age	Range of length	Mean length	Range of length	Mean length	Number of ring	Calculated length	Actual length	Calculated length	Actual length
Length in mm.	mm.	mm.	mm.	mm.		mm.	mm.	mm.	mm.
					1	121		173	
					2	173		214	218
3			266〜285	275	3	214		244	254
4			316〜375	357	4	244	244	271	297
5	350〜379	370	386〜405	395	5	269	275	301	317
6	350〜469	391	394	394	6	297	318	318	332
7	390〜469	425			7	313	329	338	397
					8			356	342
Standard of measurement	Fork length		Total length			Body length			

* Atka-fish and Its Fishery, Hokkaido Fish. Sci. Inst., 1953

group there reconized the "lst" ring that has mode at 1.0 mm. on radius of scale, and in another group the "Ist" ring is obscure or can not be found perfectly.

ii) Given the existence of the "lst" ring on all scales, the "2nd" ring (The same meaning applies correspondingly to the following parenthesized passages.), the "3rd" and the "4th" ··· are on the whole formed during the period from January to March; they are formed one a year.

iii) The actual body length when rings more than the above "2nd" are formed are given in table 12; the growth is better so far as "three-ring" group, but in groups over "three-ring" it drops to within the range from 2 to 3 cm. a year.

Table 12 Mean value of actual body length of atka-fish, when each ring has been formed.

Number of rings	2	3	4	5
	mm.	mm.	mm.	mm.
♀	214	292	326	347
♂	218	285	313	329

iv) In groups more than "three-ring", the growth of male is, to some extent, better than female.

How old is "hokke" when the "2nd" ring are formed ? That is the point. The study circle for "hokke" of Hokkaido Reg. Fish. Res. Lab. (1956) has concluded this "hokke" to be full two years old. Namely, the staffs reported that of small and large larvae caught extending over spring to autumn, larvae just after hatch and larvae with several centimeters in body length are undoubtedly 0 age fish, and larvae, ranging from 14 to 19 cm. in total length, caught around Rishiri Is. and Rebun Is. in June are clearly one year old. They reported also that at least, some of the full three years old mature sexually.

The authors, to study the growth of "hokke" in larval stage, arrange the total length or body length of smaller and larger and adult "hokke" collected throughout the whole Japan Sea, the Okhotsk Sea and the Pacific, in the process of months (fig. 16). The drawing of figure 16 is based on the following data.

i) The data with "maru-chi" net contained in table 5.

ii) The data of larvae quotated in Clause 4.

iii) The data of body length composition around Hokkaido (Hokkaido Reg. Fish. Res. Lab., et al, 1952, 1953, 1954).

iv) The data of body length composition on the catch at Ajigasawa, Aomori Pref. and. and Niigata, Niigata Pref. (Japan Sea Reg. Fish. Res. Lab., 1956).

The recognition on the growth of "hokke" larvae deduced from fig. 16 differs remarkably, at the following points from the foregoing study circle of Hokkaido Reg. Fish. Res. Lab..

* For instance, Takemura (1952 a) reported, on the basis of studies by polarization microscope, that as there found another one of ring between each winter zone on scale, any relation between number of rings and body length can not be observed.

i) Larvae ranging from 10 to 20 cm. caught in settle nets of neritic regions during June and July are regarded as O age fish. The staffs of Hokkaido Reg. Fish. Res. Lab. conclude the larvae with this size as one year old fish ; it has supporting evidence in the actual fact that one month or two months before the above period (June~July), larvae with several centimeters are caught by "maru-chi" net and it seems out of the bounds of possibility to the larvae grow up to 15 cm. or so in the scant period from one to two months, and that the length composition of each group is clearly isolated. But as understood plainly from table 5 and figure 16, around Hokkaido "hokke" larvae just after hatch occur during the pretty long period from December to April. Consequently it is quite within the bounds of possibility that in spring larvae of all sizes occur together.

The reason why relatively large larvae have not been obtained around Hokkaido, during from December to April, lies in the fact that as previously stated, towings in this period have been little made but in specific narrow area in the neritic waters, and that during the period from December to February the limited towings have been made only by day.

ii) Nextly, so called "rôsôku-bokke", the smallest "hokke" in comm- ercial catch, with mode ranging from 20 to 22 cm. in body length will not be two years old but fish between O-age and I-age fish. If it is two years old, I age fish with the middle size between such a large fish and larvae just after hatch has to appear in the sea, in winter season. But no such a larva has been obtained so far. Rather, as shown by curve "G_0" in figure 16, it is regarded as appropriate that "hokke" larvae grow up to so called "rôsôku-bokke" toward the end of naught year old.

Then the question whether the forming of ring on a scale will coincide with the above view or not is left. As mentioned above, because of occurrence of many scales without the 1st ring, the point may be left out of consideration on these scales; namely the "2 nd" ring is in reality the earliest winter band. A view to pursue some relation between the presence of the "1st" ring and the conflicting in growth in consequence of the successive spawnings extending over a long period of time, that is, a view which the "1st" ring is formed or not owing to the mixed existence of "hokke" larvae on which scales have been formed at the very times when rings are formed and the larvae which do not yet grow to that extent, has been gainsaid by the actual fact that the position of the "1st" ring on the scale radius is so fixed, namely the "1st" ring is formed on a scale when the body length reaches a definite value (Hokkaido Reg. Fish. Res. Lab., et al, 1956).

It is essential that the time and cause of the ring forming are to be studied on the basis of larvae which the "1st" ring is being formed. As one of hypothese it is estimated also that the "1st" ring is not winter band like the "2 nd" ring

and the "3 rd" … but related to the remarkable ecological changes in larval stage (Sano, 1955).

Putting aside the question of the "1st" ring formation, from the above angle, the growth assumed by the rings on scale coincides well with the growth obtained by tracing the actual body length.*

Then, the result which is obtained by plotting, according to Walford's method, actual average length when each ring is formed (table 11), in order to check the growth in O-age stage, is given in figure 17.

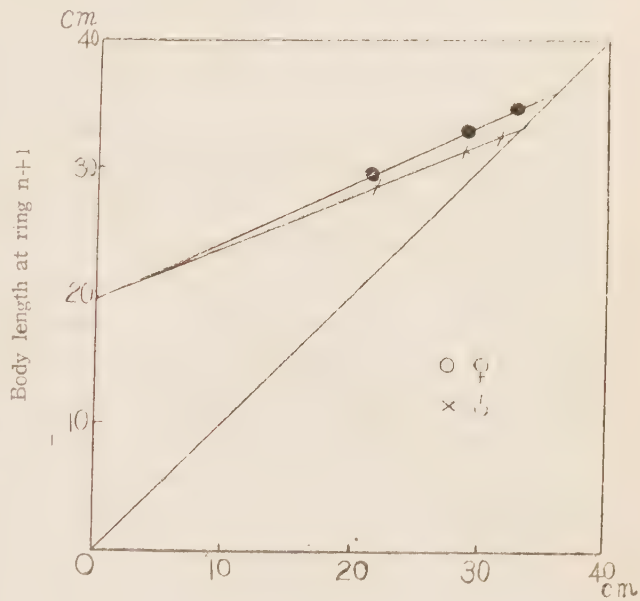


Fig. 17 Walford's growth transformation for atka-fish.

Both male and female are situated nearly on a straight line, showing propriety of the decision by Hokkaido Reg. Fish. Res. Lab., et al, (1956) on fishes over the "2nd" ring. Then, the interesting point between these straight lines and axis y, namely $\lim_{l_n \to o} \beta$ in the expression

$$l_{n+1} = \alpha l_n + \beta$$

is 200 mm. or so. This shows, considering in connection with that the total length just after hatch is about 10 mm., the adequacy of the author's view that larva will grow up to 210 mm. in full one year.

On the other hand, the maximum size of growth shown in figure 17 ranges from 360 to 370 mm.. This value is so small compared with the actual maximum shown in table 10 and figure 16 that a question is still left.

The growth of one year old larva, according to the change of mode found in length composition of the catch, can be traced as curve G_1 in figure 16. The terminus of curve G_1 coincides well with the actual body legth when the "3 rd" ring shown in table 11 is formed.

The growth of elder than two years old is only 2 or 3 cm. a year, and the length

* As usual view, in order to assume that the 1st ring is not winter band, and also that so called "rôsôku-bokke" is regarded as two years old, it is required that the earliest winter band on a scale does not be formed.

composition of each age group overlap each other. Consequently, it is incapable to pursue the growth by means of tracing the mode of length. But it is suggested that "hokke" is fairly long-lived judging from figure 16, and that the catch on the Japan Sea side of northern Honshu seems to be constituted mainly of older age group compared with that around Hokkaido.

As clearly stated above, age of "hokke" catch, in each year class, is actually younger by one age compared with the existing view. Namely "hokke" is recruited, toward the end of 0-age stage, by the groups which become the object of fishing, and at least a part matures sexually in full two years after hatch. As it is suggested that there will be remarkable change of age class in recruitment of "hokke", the conclusion is so important to biological analysis of population, and in its turn to the prediction of fishing conditions.

9 Summary

1) In the General Survey on the Warm Tsushima Current, horizontal towings of "maru-chi" net at the sea surface are made once a month through the East China Sea, the Japan Sea and Okhotsk Sea. Here the larvae occurrence is stated on the basis of samples at 3,762 stations in total, comprising 3,170 samples (stations) in total, of which the bulk was identified by H. Fukataki, one of the authors, collected on the Japan Sea side of Honshu during the period from April, 1953 to July, 1956 and 692 samples, identified by Hokkaido Reg. Fish. Res. Lab. (1955, 1956), collected in the surrounding waters of Hokkaido during May, 1953～November, 1955. The content stated here is much insufficient because of the spatial blanks and that of time, the details must depend much upon the comming investigations.

2) Eggs of "hokke" can not be collected in present horizontal towings of "maru-chi" net at the sea surface, for they go down to the sea floor and get together massively. The occurrence period of "hokke" larvae is from February to May on the Japan Sea side of Honshu and from December to May on the same side of Hokkaido.

3) The southern-most end of their occurrence is placed around Noto Peninsula, Ishikawa Pref., on the Japan Sea side of Honshu and around Kinkazan, Miyagi Pref., on the Pacific side of Honshu, this coincides well with that of their commercial landing. Meanwhile, the northern-most end has not been ascertained.

4) The occurrence region of adult "hokke" that have began to live their bottom life is much confined, while that of larvae is considerably wide.

5) The most main spawning ground is certainly the Japan Sea side of Hokkaido, also the best spawning season is certainly the period from October to December in the same region.

6) "Hokke" lavae are obtained within the range from 2° to 12°C. (surface wter temperature), especially below 6°C. level, on the Japan Sea side of Honshu, and from

4° to 8.9°C., on the same side of Hokkaido; namely the upper limit of the latter is lower than that of the former. On the other hand, the lower limit of occurrence in the two regions is probably lower than 2°C.. Larvae occur also in 11°C. level region, on the Okhotsk Sea side of Hokkaido.

7) Viwed in the chlorinity of the sea surface, "hokke" larvae occur in regions over 17.8 ‰, centering around 18.8 ‰.

8) Number of larvae obtained per tow and so is larger at night than in the day time.

i) Larvae smaller than 30 mm. in total length are caught day and night.

ii) Larvae larger than 30 mm. in total legth are little obtained in the daytime.

iii) Larvae larger than 50 mm. in total length are obtained only at night (18:00~03:00).

9) The growth in the larval stage has been studied, discussing about the present interpretation and a ameliorated view is mentioned. So age of "hokke" catch, in each year class, is actually younger by one age compared with the existing view.

10 Literature*

1. Abe, T. (1951). Notes on the young of the "hokke" *Pleurogrammus azonus* Jordan et Metz. *Bull. Jap. Soc. Sci. Fish.* **16** (11). In English.
2. Abe, T. & Z. Ichikawa (1952). Preliminary report on the tagging experiments of the "hokke", *Pleurogrammus azonus* Jordan et Metz, carried out in Japan Sea off the coasts of Noto. *Spec. Pub. Japan Sea Reg. Fish. Res. Lab. on the 3rd Anniv. of Its Founding.* In Japanese.
3. Abe, T. (1953). Occurrence of *Pleurogrammus azonus* Jordan et Metz along the Pacific coast of the northern part of the mainland of Japan. *Jap. Jour. Ichtyology.* **3** (1). In Japanese.
4. Belchouk, L. A. (1938). Contribution on age determination of *Pleurogrammus azonus. Bull. Pacific Sci. Inst. Fish. Oceanog.* **XIV**. In Russian. (Cited from T. Abe, 1951).
5. Esterly, C. O. (1912). The occurrence and vertical distribution of the Copepoda of the San Diego region with particular reference to nineteen species. *Univ. Calif. Publ. Zool.* **9** (6). In English.
6. Hirano, Y. & T. Takahashi (1943). Some observations on the "hokke". *Hokkaido Suisan Shikenjo Junpo.* **5**. In Japanese.
7. Hirano, Y. & T. Takahashi (1947). *Hokkaido no hokke ni tsuite* (On the atka mackerel of Hokkaido). *Hokusuishi Geppo.* **4** (1).
8. Hirano, Y. & H.Kondo (1948). On the development of atka mackerel eggs.

* For publications with no English title, the Japanese title is given in italics and the translation thereof in parentheses.

Ibid. **5** (3). In Japanese.

9. Hokkaido Reg. Fish. Res. Lab., Hokkaido Fish. Sci Inst. & Hokkaido-ku Soko-uo Shigen Kenkyu Shudan. (1952). *Ito soko-uo shigen chosa* (Fisheries biological survey on the bottom fishes east of 130°E). I. *Hokkaido-ku Shigen Chosa Yoho.* **3**.

10. Hokkaido Reg. Fish. Res. Lab., Hokkaido Fish. Sci. Inst. & Hokkaido-ku Soko-uo Shigen Kenkyu Shudan. (1953). *Ditto.* 2. *Ibid.* **6**.

11. Hokkaido Fish. Sci. Inst. (1953). *Hokke to sono gyogyo* (Atka fish and its fishery). *Gyogyo Shido Shiryo.* **2**.

12. Hokkaido Reg. Fish. Res. Lab. (1954). *Gyorui sekitsui-kotsu-su hyo* (Table on the number of fishes' vertebrae). 1. Mimeographed.

13. Hokkaido Reg Fish. Res. Lab., Hokkaido Fish. Sci. Inst. & Hokkaido-ku Soko-uo Shigen Kenkyu Shudan. (1954). *Ito soko-uo shigen chosa* (Fisheries biological survey on the bottom fishes east of 130°E). 3. *Hokkaido-ku Shigen Chosa Yoho.* **9**.

14. Hokkaido Reg. Fish. Res. Lab., Hokkaido Fish. Sci. Inst. & Hokkaido-ku Soko-uo Shigen Kenkyu Shudan. (1955). Hokke (Atka fish). *Hokkaido-ku Ito Soko-uo Shigen Chosa Keika Hokoku.*

15. Hokkaido Reg. Fish. Res. Lab. & Hokkaido Fish Sci. Inst. (1955). *Tsushima-danryu-sui'iki no kaihatsu ni kansuru kenkyu*(Studies in the on the development warm Tsushima Current regions). 2. *Showa 28-nendo. Hokkaido-ku Shigen Chosa Yoho.* **11**.

16. Hokkaido Reg. Fish. Res. Lab. & Hokkaido Fish. Sci. Inst. (1956). *Ditto.* 3. *Ibid.* **13**.

17. Hokkaido Reg. Fish. Lab., Hokkaido Fish. Sci. Inst. & Hokkaido-ku Soko-uo Shigen Chosa Kenkyu Shudan. (1956). *Hokkaido no Kisen-sokohiki-ami to sono shigen* (Trawl fisheries of Hokkaido and its stock).

18. Kaganowsky, A. G. (1936). On the occurrence of *Pleurogrammus azonus* near the surface in southern Primorskaya. *Bull. Far Eastern Branch Acad. Sci. U. S. S. R.* **XViii.** In Russian (Cited from T. Abe, 1951).

19. Kambara, H. (1950). *Hokkaido Taiheiyo-gan no hokke yogyo ni tsuite* (On atka-fish larvae on the Pacific side of Hokkaido). *Hokkusuishi Geppo.* **7** (11).

20. Kambara, H. et al. (1953). Studies on the hokke (*Pleurogrammus azonus* Jordan et Metz). *Bull. Hokkaido Reg. Fish. Res. Lab.* **9**. In Japanese.

21. Matsubara, K. (1955). Fish morphology and hierchy. 1-Ⅲ Ist ed. Tokyo. Ishizaki Shoten. In Japanese.

22. Nakamura, S. (1936). *Kominato fukin ni arawareru iso-uo no yoki* (Young stages of the littoral fishes appearing around Kominato). XIV. *Yoshoku Kaishi.* **6** (7, 8). In Japanese.

23. Ogata, T. (1956). *Hokke* (Atka fish). *Japan Sea Reg. Fish. Res. Lab.* **4**.

24. Oshima, Y. & N. Nakamura (1944). On the life history of *Hexagrammus otakii* Jordn et Starks. *Suisan Gakkai Ho.* **9** (2-4). In Japanese.

25. Sano, O. (1956). On the development of brain pattern of the atka mackerel, *Pleurogrammus azonus* Jordan et Metz (1). *Bull. Hokkaido Reg. Fish. Res. Lab.* **13**. In Japanese.

26. Takemura, Y. (1952 a).. Observation of the scale of the "hokke", *Pleurogrammus azonus*, by the use of polarized light. *Bull. Jap. Soc. Sci. Fish.* **17** (12). In Japanese.

27. Takemura, Y. (1952 b). On the ovary of atka mackerel, *Pleurogrammus azonus* Jordan et Metz. *Ibid.* **18** (1). In Japanese.

28. Tamura, T. & S. Okubo (1952). *Shunki nishin-gyoba ni okeru hokke no shokusei ni tsuite* (Studies on the feeding habits of atka fish caught in herring ground of Hokkaido). *Sci. Rep. Hokkaido Fish Hatchery.* **7** (1, 2). In Japanese.

29. Taranetz, A. J. (1937). Handbook for identification of fishes of Soveet Far East and adjacent waters. *Bull. Pacific Sci. Inst. Fish. Oceanog.* **11**. In Russian and English.

30. Tomabeti, H. & I. Kojima et al. (1952). *Suion to suketo-dara oyobi hokke no bunpu* (Relations between water temperature and the distribution alaska pollack & atka fish). *Hokusuishi Geppo.* **9** (9).

31. Uchida, K. (1929), *Gyorui ni okeru yoki tekio no shuju-so* (Various adaptations of larval fishes to the environments). *Zoolog. Mag.* **41** (490, 491).

32. Yamamoto, G. & C. Nishioka (1948). Breeding habits and developmental processes of greenling, *Hexagrammus otakii* Jordan et Starks. *Seibutsu.* **3** (5). In Japanese.

Appended Table to Table 5

Region		Japan Sea side of Honshu						Surrounding waters of Hokkaido									
Sub-region		Northern region (north of Ishikawa Pref.)				western region		Japan Sea side				Okhotsk Sea side				Pacific side	
Month	Year \ Item	A No. of total sts., at which towings were made	B No. of sts. at which larvae were obtained.	C Number of larvae	D Range of total length	A	B	A	B	C	D	A	B	C	D	A	B
Jan.	**Total**	23	0	0	mm.	92	0	5	5	174	9～27mm	0	0	0	mm.	0	0
	1953	0	0	0		32	0	0	0	0		0	0	0		0	0
	1954	11	0	0		26	0	0	0	0		0	0	0		0	0
	1955	8	0	0		9	0	5	5	174	9～27	0	0	0		0	0
	1956	4	0	0		25	0										
Feb.	**Total**	93	3	23	10～15	134	0	5	3	41	11～31	0	0	0		0	0
	1953	2	0	0		38	0	0	0	0		0	0	0		0	0
	1954	0	0	0		29	0	0	0	0		0	0	0		0	0
	1955	84	2	22	10～15	33	0	5	3	41	11～31	0	0	0		0	0
	1956	7	1	1		34	0										
March	**Total**	146	51	509	8～74	137	0	2	2	33	14～22	0	0	0		0	0
	1953	0	0	0		22	0	0	0	0		0	0	0		0	0
	1954	41	11	157	8～41	36	0	0	0	0		0	0	0		0	0
	1955	50	16	70	9～74	35	0	2	2	33	14～22	0	0	0		0	0
	1956	55	24	282	8～38	44	0										
April	**Total**	213	69	847	9～100	250	0	26	21	453	17～33	0	0	0		0	0
	1953	11	4	9	9～95	58	0	0	0	0		0	0	0		0	0
	1954	43	12	73	10～100	79	0	26	21	453	17～33	0	0	0		0	0
	1955	55	12	31	10～26	54	0	0	0	0		0	0	0		0	0
	1956	104	41	734	10～70	59	0										
May	**Total**	200	7	48	15～71	262	0	46	8	331	27～119	0	0	0		0	0
	1953	27	0	0		82	0	36	8	331	27～119	0	0	0		0	0
	1954	55	3	3	20	51	0	10	0	0		0	0	0		0	0
	1955	50	1	1	15	78	0	0	0	0		0	0	0		0	0
	1956	65	3	44	21～71	51	0										

	Total	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
	1953	56	0	0		55	0	25	0	0		0	0	0			
June	1954	39	0	0		41	0	70	0	0		15	[illegible]	40	23~68	0	0
	1955	30	0	0		74	0	86	0	0		0	0	0		0	0
	1956	42	0	0		41	0										
	Total	**169**	**0**	**0**		**177**	**0**	**101**	**0**	**0**		**73**	**2**	**5**	**136~161**	**0**	**0**
	1953	22	0	0		37	0	24	0	0		0	0	0			
July	1954	57	0	0		43	0	25	0	0		32	1	[illegible]	150		
	1955	34	0	0		56	0	52	0	0		41	1	[illegible]	1 36~161		
	1956	56	0	0		41	0										
	Total	**54**	**0**	**0**		**189**	**0**	**104**	**0**	**0**		**35**	**0**	**0**		**21**	**0**
Aug.	1953	0	0	0		45	0	34	0	0		18	0	0		0	0
	1954	9	0	0		54	0	62	0	0		17	0	0		21	0
	1955	45	0	0		9	0	8	0	0		0	0	0		0	0
	Total	**70**	**0**	**0**		**114**	**0**	**18**	**0**	**0**		**4**	**0**	**0**		**10**	**0**
Sept.	1953	12	0	0		26	0	0	0	0		4	0	0			0
	1954	36	0	0		55	0	0	0			0	0	0			0
	1955	22	0	0		33	0	18	0	0		0	0	0			0
	Total	**60**	**0**	**0**		**139**	**0**	**36**	**0**	**0**		**21**	**0**	**0**		**0**	**0**
Oct.	1953	20	0	0		52	0	0	0	0		0	0	0		0	0
	1954	26	0	0		40	0	27	0	0		21	0	0		0	0
	1955	14	0	0		47	0	9	0	0		0	0	0			0
	Total	**49**	**0**	**0**		**96**	**0**	**9**	**0**	**0**		**0**	**0**	**0**		**0**	**0**
Nov.	1953	10	0	0		30	0	0	0	0		0	0	0		0	0
	1954	22	0	0		22	0	5	0	0		0	0	0		0	0
	1955	17	0	0		44	0	4	0	0		0	0	0		0	0
	Total	**44**	**0**	**0**		**84**	**0**	**5**	**3**	**42**	**8~10**	**0**	**0**	**0**		**0**	**0**
Dec.	1953	8	0	0		26	0	0	0	0		0	0	0			0
	1954	27	0	0		22	0	5	3	42	8~10	0	0	0		0	0
	1955	9	0	0		36	0	0	0	0		0	0	0		0	0

Chapter V "Ika" (Squids)

In the samples captured by the surface towing of "maru-chi" net for taking eggs and larvae, spheroidal pelagic eggs of squids are found very often, and their larvae also found though a small number. Here the occurrence conditions of squid-eggs and larvae are studied, basing upon the total samples amounting to 972 that captured in the warm Tsushima Current regions of the Japan Sea during the period January～December, 1955.

1 Classification of squid-eggs

Cephalopoda eggs are classified into the following groups, from their morphogical and ecological standpoint of view(Yamamoto, 1943).

(1) pelagic eggs.

(2) adhesive eggs.

(i) adhesion by viscous substance outside of egg-membrane.

(ii) adhesion by gelatinous case enveloping many eggs separated each other.

(iii) adhesion by gelatinous peapod-like case containing many eggs.

(iv) adhesion by long thready stalk.

In the past studies, the squid corroborated to lay pelagic eggs is only "hotaru-ika". one of luminous squids, (*Watasenia scintillans* (Berry)) alone. Nishikawa (1906 b) reported the eggs captured in the sea and the results of artificial fertilization (but this experiment miscarried) and Matsuno (1915) embryonal development within eggs, and Yamamoto (1943) also reported that the same eggs distributed widely along the east coast of Korea. From these reports, it is clear that eggs of *Watasenia scintillans* are spheroidal. But their sizes differ as follows.

(1) 2.0 by 1.5 mm. (Nishikawa, 1906 b)

(2) 1.5 by 1.2 mm. (Sasaki, 1913)

(3) 1.53 by 1.30 mm. (Yamamoto, 1943)

Of these values, (1)is based on the materials on the Pacific coast, and (2) and (3) on the Japan sea coast; the former is larger than the latter.

Nishikawa (1906 b) estimated that, on the basis of the fact that eggs of *Watasenia scintillans* are pelagic, common squid (*Ommastrephes sloani pacificus* Steenstrup) belonging to the same group, Decapoda Oegopsida, also should lay pelagic eggs. But according to the latest study (Soeda, 1956), the matured eggs in body cavity of common squids are 0.78 by 0.75 mm. in dimensions, being smaller than *Watasenia scintillans*' eggs, and the eggs taken out of body cavity, view to study their artificial fertilization, after fertilized, did not float but sinked in the still sea water.

No eggs of common squids laid in nature have been yet found, but in the above-mentioned report, Soeda estimated that, on the basis of the arrangements of various

internal organs, the properties of nidamental gland, oviduct and others, the separated eggs carried out of the mouth of oviduct into mantle cavity, after fertilized would be burried in a mass of secretions derived from nidamental gland, then being carried out of the mantle through infundibulum, and that lastly they would be attached (spawned) on the rocks and others at the sea bed.

Eggs of squids belonging to Decapode-Myopsida, according to the past studies, belong all the (i)-, (ii)- or (iii)-type of adhesive eggs mentioned previously. Eggs of "tako" (Octopus, Octopoda) belong to the (iv)-type (Nishikawa, 1906a ; Yamamoto, 1942, 1943 and so like).

On the pelagic eggs of squids dealt in this study, their forms and sizes coincide well with the data of eggs of *Watasenia scintillans* reported dy Sasaki (1913) and Yamamoto (1943). Then in Toyama Bay, at the very least, as will be mentioned after, the occurrence season of their eggs also accords well with the fishing season by settled nets. On the other hand, the majority of the the *Watasenia* catches in Toyama Bay is composed of well matured female, or female bearing spermatophore by copulation, and the season when they come near the coast for the purpose of spawning is their fishing season (Sasaki, 1913).

As the eggs of its consanguineous species have not been identified satisfactorily, it should be reserved to decide that the Decapoda eggs dealt in this study belong all to that of *Watasenia scintillans*. But it may be sure that the eggs will belong to *Watasenia scintillans*' or its consanguineous species'.

2 Occurrence seasons of pelagic eggs of Decapoda

The number of materials obtained during the period January~December, 1955 are 972 in total. Of those, 56 materials captured by Kyoto Fu Fisheries Experimental Station are ruled out, owing to impossibility of microscopic examination; namely the remaining 916 materials are available for this chapter. The occurrences of pelagic eggs of Decapoda found in the 916 materials are summarized as given in table 1.

Table 1 shows that the main occurrence period is limited in the warmer season from March to August, forming a peak in May~June, and that in September the number of eggs diminishes steeply, bearing only the marks of occurrence from September onward.

Then, table 2 shows the number of eggs for each region, each month, and per each station where "maru-chi" net was towed. Although the geographical distribution covers about the whole areas (the warm Tsushima Current regions) along Honshu, the main occurrence regions are the following three.

Toyama Bay.

Wakasa Bay.

Region from Hyogo Pref. to Shimane Pref.

Of these three regions, the height of prosperity in Toyama Bay differs from the

Table 1 Occurrene and numher of squip eggs, by month, in towings made during 1955.

Month	No. of total sts., at which towings were made.	(A) No. of sts., at which identifcations of eggs were made.	Squid eggs (B) No. of sts., at which eggs were obtained.	Squid eggs (C) Number of eggs	(B)/(A) (%)	(C)/(A)
Total	1,012	953	188	4,923	19.7	5.2
Jan.	17	17	0	0	0	0
Feb.	123	117	24	70	20.5	0.6
March	82	74	17	201	23.0	2.7
April	109	104	26	631	25.0	6.1
May	128	120	37	2,208	30.8	18.4
June	103	95	28	1,438	29.5	15.1
July	90	82	23	248	28.0	3.0
Aug.	140	132	24	117	18.2	0.9
Sept.	55	52	2	2	3.8	0
Oct.	61	61	2	3	3.3	0
Nov.	61	61	3	3	4.9	0
Dec.	43	38	2	2	5.3	0.1

Table 2 Number of pelagic squid eggs per tow, by month and sea area, in 1955.

Sea area / Month	Aomori ~ Niigata	Toyama Bay	Ishikawa	Wakasa Bay	Hyogo ~ Shimane	Yamaguchi
Jan.	—(1)	0	—	0	0	—
Feb.	0	1	0	0	0	—
Mar.	0.03	8	—	10	1	0
Apr.	0.5	39	0.2	28	3	0
May	0.4	30	0.1	179	26	0.3
June	0.2	3	3	101	16	0
July	1	3	1	3	7	0
Aug	0.1	—	0	0	0	0.1
Sept.	0.2	0	—	0	0	—
Oct.	0	0	0	0.3	0.1	0
Nov.	0	0.2	0	0.3	0	0
Dec.		0.3		0	0	0

(1) ; Marks—designate no towing.

other two regions, being found a time lag. Namely, in Toyama Bay the period during April~ May is the season for Decapoda eggs; but in Waksa Bay and the region from Hyogo Pref. to Shimane Pref., May~June is the season. Considering in connection with Yamamoto's report (1943), there is an indication that the best season in the

northern sea comes earlier than in the southern.

3 Occurrence regions of pelagic eggs of Decapoda

The positions of stations towed in each month are the very same as that of anchovy (cf. Chapter 1 Anchovy); the number of Decapoda eggs also are given in figures 1~13. The northern-most end of the distribution, from a latitude point of view, is situated roughly in lat. 41° N. as that of anchovy. The southern most end lies around Tsushima Is. in May (fig. 6). Therefore it may be sure that Decapoda eggs, seeing all the year around, are laid in the whole area along the west coast of Honshu.

As number of stations towed in each month is irregular, it is impossible to go into details, but the occurrence conditions of eggs are summarized as follows.

i) During the period September~January, the occurrence is just a very little.

ii) Already in February, the period of the lowest surface water temperature in the year eggs are captured. But the distribution is limited in the region west of Toyama Bay; till early in April, the geographical difference in the ocurrence can not be seen, but they are collected simultaneously only in the regions west of Toyama Bay.

iii) In May, as in the occurrence of anchovy eggs, the distribution of Decapoda eggs, with start of mighty northing of the warm Tsushima Current along the west coast of Honshu, spreads swiftly toward the north, reaching around Nyudo Saki, Akita Pref.. Such a condition lasts into July.

iv) In August, it spreads furthermore toward the north, reaching near Henashi Saki, Aomori Pref.. It should be noticed that the occurrence in the neritic regions is limited only in the particular regions north of Noto Peninsula, while no eggs can be seen in the region west of Noto Peninsula, and that the distribution region removes to the offshore regions (the offshore branches of the warm Tsushima Current) throughout the Japan Sea-it removes to the regions below 25°C. of surface water temperature. Then, it should be noticed also that in the regions west of Yamaguchi Pref., the occurrence of Decapoda eggs is seen only in May.

v) From September on, the number of eggs diminishes rapidly, although they are collected always in Toyama Bay.

In the west region of the Japan Sea, it may be sure that the eggs will be laid in the offshore region across the present survey region, already in February, when, in the neritic region, spawning begins.

In the offshore and the neritic region along the east coast from Keishō North (Keisho Hokudo) to Kankyō—North (Kankyo Hokudo), Korea —from lat. 36°N. to lat. 41°N.——, eggs of *Watasenia scintillans* are collected during the period May~September (Yamamoto, 1943). Therefore cosidering in connection with Shimomura's report(1957), it is estimated that their distribution overspreads widely in the Japan Sea, not

only in the warm Tsushima Currenr but also in the cold Liman Current regions across the Liman Front (polar front), if they are, to any extent, affected by the warm Tsushima Current.

But the main occurrence regions in the Japan Sea are the following four;

i) along the west coast of Honshu (table 2, figs.1~13).

Toyama Bay

Wakasa Bay

the sea regions from Hyogo Pref. to Shimane Pref.

ii) along the east coast of Korea (Yamamoto, 1943)

Keishō-North (Keisho Hokudo)

As previously stated, the fishing season of *Watasenia scintillans* in Toyama Bay is the spawning season, and the fishing for *Watasenia scintillans*, a speciality in Toyama Bay, is operated with settled nets during the period March~July, forming a peak in May (table 3). This fishing season coincides well with the occurrence season of the pelagic eggs of Decapoda in the Bay.

Table 3 Landing of "hotaru-ika", *Watasenia scintillans* (Berry), in Toyama Bay (1)

(unit: 100 kan=375 kgs.)

Year / Month	1951 (2)	1952	1953	1954	1955	1956	Average
Total	1,301	5,595	3,869	6,499	5,457	6,369	4,843
Jan.	—	0	0	4	0	0	0.8
Feb.	—	0	0	4	1	0	1
Mar.	—	31	6	215	81	56	78
Apr.	305	1,181	1,022	2,381	1,977	2,399	1,544
May	842	3,357	2,481	2,852	3,018	3,270	2,637
June	144	1,016	352	926	378	644	577
July	10	9	2	114	0	0	23
Aug.	0	0	0	0	0	0	0
Sept.	0	0	0	0	0		0
Oct.	0	0	0	0	0		0
Nov.	0	0	0	0	0		0
Dec.	0	0	3	0	0		0.5

(1) From statistical survey by Ministry of Agriculture and Forestry, Japan.

(2) Landing from January to March, 1951, was not surveyed.

In Wakasa Bay and the regions from Hyogo Pref. to Shimane Pref., no *Watasenia scintillans* have been caught by fishermen, unlike in Toyama Bay. But in the stomach contents of alaska pollack, *Teragra chalcogramma* Pallas, landed at Kasumi, a famous fishing port for trawling in Hyogo Pref. during the period September~October, a good many of *Watasenia scintillans* was found (table 4). Ogata (1956) also reported that in the regions from Niigata Pref. to Ishikawa Pref., including Toyama Bay, *Watasenia*

scintillans swallowed by alaska-pollacks were found in their stomach contents all the year around.

But the authors have some doubt about the identification of *Watasenia scintillans* (Berry) in table 4, for a good many of squids swallowed in stomachs of alaska-pollacks caught by Capt. Kiroku Tabata, during the long line fisheries examination in June, 1956, were identified as another species, *Enoploteuthis chunii* Ishikawa, belonging to the same family as *Watasenia scintillans*, by Mr. Toshiaki Otsuki of Hokkaido Regional Fisheries Research Laboratory. Therefore the identification of this species requires further examination.

Table 4 Number of *Watasenia scintillans* (Berry) found in the stomachs of alaska-pollacks.

Pref.	Number of Alaska-pollacks surveyed	Number of Alaska-pollacks Swallowed *Watasenia scintillans*	Number of *Watasenia scintillans*
Akita	718	0	0
Niigata	2,904	90	184
Ishikawa	504	8	12
Hyogo	462	98	258

(after Soko-uo shigen chosa yoho—Sept., 1954~May,1955)

4 Occurrence of pelagic larvae of Decapoda

The occurrence conditions of squid-larvae resolve themselves into the following three points (table 5).

i) Squid larvae occur, except March, throughout the year.

ii) The number of larvae obtained abounds in May and September.

iii) The body-sizes are larger in spring than in autumn (although the body-sizes in table 5 are given by total length including arm and mantle, the maximum value of dorsal length of mantle is 39.5mm. in May, which measured by Hiroshi Fukataki, one of the authors).

Table 5 Occurrence and number of squid larvae, by month, in towing made during 1955.

Month	No. of total sts., at which towings were made.	No. of sts at which larvae were obtained.	Number of larvae	Range of total length including arm.
Total	1,012	71	261	mm. 1~58
Jan.	17	1	6	13~14
Feb.	123	4	5	15~39
Mar.	82	0	0	—
Apr.	109	6	9	5~29
May	128	16	103	6~58
June	103	5	5	11~30
July	90	6	9	6~18
Aug.	140	7	22	*(2~25)
Sept.	55	12	60	1.5~15
Oct.	61	3	4	2~30
Nov.	61	4	21	12~21
Dec.	43	7	17	1~26

*Range of dorsal length of mantle.

Taking all the past studies (Yamamoto, 1943; Hayashi & Iizuka, 1953, etc.) together, it is estimated that those squid larvae consist of several species of Decapoda, judging from their occurrence periods, dorsal lengths of mantle, and morphological characters. But at present it is impossible to definitely identify larvae belonging to various species of squids, so the authors have plan to accumulate another plentiful samples and study, for the future.

Table 6 Temperature range for the occurrence of squid egg.

Month / Temp. range	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Number of eggs per tow (station)
10°C～		6 23	5 81	7 292									18 396	22
11～		9 27	5 35	7 116									21 178	9
12～			3 66	4 140	1 2								8 208	26
13～			4 19	5 22	10 301								19 342	38
14～				2 25	5 230								7 255	37
15～				1 36	10 868							2 2	13 906	70
16～					3 688	1 1					1 1		5 690	138
17～					6 106	4 17					1 1		11 124	11
18～					2 13	6 739					1 1		9 753	84
19～						7 222							7 222	32
20～						4 53				2 3			6 56	9
21～						6 406	6 23						12 429	36
22～							5 117						5 117	24
23～							6 77						6 77	13
24～							4 14	6 25					10 39	4
25～								12 73	1 1				13 74	6
26～							2 17	6 19					8 36	5
27～									1 1				1 1	1
Un-known		9 20											9 20	
Total		24 70	17 201	26 631	37 2,208	28 1,438	23 248	24 117	2 2	2 3	3 3	2 2	188 4,913	27
Number of eggs per station	0	3	12	25	60	52	11	5	1	2	1	1	27	

Upper numeral in each measure idenotes the number of stations at which squid egge were obtaned; lower the number of total eggs throughout the whole area under study,

5 Relation between the occurrence of eggs & larvae and the sea conditions

Both pelagic squid eggs and larvae, as previously stated, occur all the year around except January. But it is impossible to conclude that they do not occur really in January; for the towings are few in January owing to seas and number of stations towed is different from month to month. Consequently, it is impossible to go into details.

The following clauses deal with general principles in the relations.

1) **Relation between pelagic squid-eggs and surface water temperature** (table 6).

i) Squid eggs in the Japan Sea occur only within the range from 10° to 27°C.. In the Japan Sea the surface water temperature, even in summer, does not rise above 28°C. except small dependent inlets. Therefore the maximum temperature for the occurrence is 27°C. and the minimum 10°C..

ii) Both the maximum temperature for occurrence of pelagic squid eggs and the minimum continue to rise up to September with the process of months. From October on they fall together, especially the falls in October are so large that the maximum falls as much as 7°C. compared with in September. On the other hand, the remarkable rises of the maximum and the minimum are found during the period May~August, showing the range of 5°C..

iii) The temperature range for the occurrence of pelagic squid-eggs is largest during the period April~July, showing the range from 6° to 7°C.. The smallest is seen during September~February, showing the range from 1°~2°C..

iv) The optimum temperature for the occurrence of eggs lies between 15°C. and 21°C., especially between 15°C. and 18°C..

v) It is difficult to find some rule in the scattering of the stations, at which pelagic eggs were found, by water temperature range. But number of statoins by month is exceptionally large (more than 20) during the period from February to August and decreases in extreme (1 or 2 stations) during September~January.

vi) Number of pelagic squid-eggs per tow does not show any clear difference among water temperature ranges, but, by month, it increases strikingly from March on, showing the peak (more than 50) during the period from May to June.

2) **Relation between pelagic squid-eggs and surface chlorinity** (table 7).

i) The maximum chlorinity and the minimum for occurrence of pelagic squid eggs are 14.0‰ and 19.2‰ mark, respectively. But the maximum and the minimum show no rise with the progress of months, unlike in the case of temperature. From June on the maximum goes on falling, being limited within the range 18.0‰~19.0‰. Namely the falling of the maximum starts earlier by four months than in the case of water temperature. This phenomenon is caused by the general lower salty season of the surface layer of the warm Tsushima Current in summer, originating in no any locally special features.

ii) In the Japan Sea, even the maximum chlorinity does not rise above 19.3‰.

Fig 7 Chlorinity range for the occurrence of squid eggs.

Month / Cl range	Jan.	Feb.	Mar.	Apr.	May	June	July	Acg.	Sept.	Oct.	Nov.	Dec.	Total	Number of eggs per station
‰ 14.00~							1 2						1 2	2
15.00~							3 11						3 11	4
16.00~				1 108									1 108	108
17.00~			1 22				1 4	1 4					3 30	10
17.50~				2 40	2 190	1 12						1 1	6 243	41
18.00~			1 49	2 224		1 3	3 21		1 1	2 3	3 3	1 1	14 305	22
18.50~			2 29	1 12	2 3		1 2	1 1					7 47	7
18.60~				1 12	2 59		2 70	4 15					9 156	18
18.70~			3 12	3 5	3 22	1 8	4 10	8 44	1 1				23 102	5
18.80~			2 3	3 116	1 2	4 22	3 23	8 28					21 194	10
18.90~			4 67	2 19	4 254	1 18	5 105	2 25					18 488	27
19.00~			1 3	4 13	7 753	5 59							17 828	49
19.10~			3 16	6 46	8 150	14 953							31 1,165	38
19.20~				1 36	7 773	1 363							9 1,172	130
19,30~														
19.40~														
Un-known		24 70			1 2								25 72	
Total		24 70	17 201	26 631	37 2,208	28 1,438	23 248	24 117	2 2	2 3	3 3	2 2	188 4,923	26
Number of eggs per station		3	12	24	60	52	11	5	1	2	1	1	26	

Upper numeral in each measure denotes the number of station at which squid eggs were obtained; lower the number of eggs throughout the whole area under study,

The main occurrence of pelagic squid-eggs is situated in the range from 17.5‰ to 19.3‰, forming two peaks in the range from 17.5‰ to 18.5‰ and from 19.0‰ to 19.3‰. Especially, still in the latter, the range 19.1～19.3‰ constitutes the center, judging from the number of stations at which eggs were found, and of eggs.

3) **Relation between pelagic squid-larvae and surface water temperature** (table 8).

The dispersing of occurrence is alike in the case of eggs—table 6.

The occurrence of larvae are limited in the range from 9° to 26°C. level; both the maximum and the minimum are together lower as much as 1°C. compared with eggs. Squid larvae are collected all the year around. The dispersing of occurrence by water temperature range is larger than in the case of eggs, as they are capable of swimming at will. Judging from the number of stations at which larvae were found and of the individuals, the main occurrence temperature lies in the range 14°～19°C. and 24°～27°C., respectively.

4) **Relation between squid larvae and surface chlorinity** (table 9).

Alike in the case of eggs, the dispersing viewed from chlorinity is larger than that viewed from temperature angle. Squid larvae occur within the range from 16.0‰ to 19.2‰ level and the maximum appearrs in April and May, going on falling with the progress of time from June on; then from July on the occurrence is limited below 19.0‰.

6 Spawning seasons of squids

Table 6 contains the appearence of spawning seasons—the spring and the autumn; in the former, May is the nucleus of flourishing and the period is longer, but in the latter, the number of eggs is not only scarce but the period is more short; then the temperature range for occurrence of eggs in the latter is the same range from 15° to 20°C. as in spring. Namely the spawning seasons, at least two—the spring and the autumn— in the year, seems to be in existence.

On the other hand, table 8 shows peak of larvae occurrence in May, during August and September, and during the period from November on; namely the spawning seasons, at least three times in the year, seem to be in existence.

But species identifications of squid larvae are generally impossible at the early stages when dorsal length of mantle is shorter than several or about 10 mm.. Consequently, it is impossible to conclude that these various spawning seasons above mentioned are formed of single species of squid.

The squid species caught by fishermen in the Japan Sea are as follows.

"Surume-ika"	*Ommastrephes sloani pacificus* Steenstrup
"Kensaki-ika"	*Loligo kensaki* Wakiya & M.Ishikawa
"Yari-ika"	*Loligo bleekeri* Keferstein
"Aori-ika"	*Sepioteuthis lessoniana* Ferussac
"Kô-ika"	*Sepiella maindroni* (de Rochebrune)

Table 8 Temperature range for the occurrence of squid larvae.

Month / Temp range	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Number of larvae per station.
9°C~		1 1			2 2								3 3	1
10 ~													0 0	
11 ~		2 2		1 1									3 3	1
12 ~		1 2		1 1	1 2								3 5	2
13 ~	1 6												1 6	6
14 ~				4 7	4 5	1 1							9 13	2
15 ~					5 32								5 32	6
16 ~					2 6							1 2	3 8	3
17 ~					1 7	1 1					1 3	2 9	5 20	4
18 ~						1 1				2 2	2 17	3 4	8 24	3
19 ~							1 1				1 1	1 2	3 4	2
20 ~													0 0	
21 ~						2 2	3 5						5 7	2
22 ~							1 1						1 1	1
23 ~							1 2			1 2			2 4	2
24 ~								3 6	2 6				5 12	3
25 ~								3 15	6 35				9 50	6
26 ~								1 1	4 19				5 20	4
27 ~													0 0	
Un-known					1 49								1 49	
Total	1 6	4 5	0 0	6 9	16 103	5 5	6 9	7 22	12 60	3 4	4 21	7 17	71 261	4
No. of larvae per station	6	2	0	2	7	1	2	3	5	2	6	3	4	

Upper numeral in each measure denotes the number of stations at which squid larvae were obtained; lower the total of larvae throughout the whole area under study.

Table 9 Chlorinity range for the occurrence of squid larvae.

Month / Cl. range	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Number of larvae per station
‰ 14.00～													0 0	0
15.00～													0 0	0
16.00～									1 25				1 25	25
17.00～					1 2				1 3				2 5	3
17.50～									2 7				2 7	4
18.00～				1 1			1 2		5 18	1 2	1 1	1 2	10 26	3
18.50～								1 1		1 1	2 4	2 2	6 8	2
18.60～								2 5			1 16	1 8	4 29	7
18.70～					1 49	1 1	1 1		2 6	1 1			6 58	10
18.80～		3 4		2 2	3 3	1 1	1 3	1 2	1 1			1 1	13 17	2
18.90～	1 6				2 3	1 1	3 3	1 1					8 14	2
19.00～					2 12	1 1						2 4	5 17	4
19.10～				2 5	4 15	1 1							7 21	3
19.20～				1 1	3 19								4 20	5
19.03～													0 0	0
19.40													0 0	0
Un-known		1 1						2 13					3 14	5
Total	1 6	4 5	0 0	6 9	16 103	5 5	6 9	7 22	12 60	3 4	4 21	7 17	71 261	4
No. of larvae per station	6	2	0	2	7	1	2	3	5	3	6	3	4	

Upper numeral in each measure denotes the number of stations at which squid larvae were obtained; lower the total number of larvae throughout the whole area under study.

"Hotaru-ika" *Watasenia scintillans* (Berry) and so on.

There are more spesies in the Japan Sea, although they are not caught as fisheries. Then the spawning habits and developments leave much to be studied in these species.

And on the other hand, these above mentioned larvae do not seem to belong to single species, judging from the fact that body length distribution in table 5 shows fairly large differences by month, and from the frequency distribution of dorsal length of mantle, which was measured else.

Dorsal length of mantle on hatching is smallest in *Watasenia scintillans* (1.17~1.70mm.), secondly *Ommastrephes sloani pacificus* (1.70mm.); these two are the only species of 1mm. level. Other species except these two are ,in general, 3~5mm. long. Even "mimi-ika", *Euprymna morsei* Verrill, one of the smallest squids, the dosal length of mantle on hatching is 2 mm. or thereabouts (Yamamoto, 1943; Hayashi and Iizuka, 1953). Also in Toyama Bay, in spring. the season for eggs, squid larvae are not captured. The occurrence months of the bay are only September (34 individuals) and October (2 inds.) in the course of a year ; then the occurrence of larvae reaching 2 mm. level is found only in September (20 inds.). In May, the height of prosperity of eggs, squid larvae with dorsal length of mantle from 3 to 23 mm. are caught in other regions. As the accumulation of data on mantle length is now so defective, it is impossible to go into details, but judging from various aspects, the follows are supposed.

i) In the Japan Sea one or more species of squids lays eggs throughout the whole year. And number of species belonging to these squids are largest in spring.

ii) *Watasenia scintillans* surely lay eggs in spring, as previously stated. But larvae captured in autumn fairly number (tables 8 and 7) will probably belong to "surume-ika", *Ommastrephes sloani pacificus*, for dorsal length of mantle with 1 mm. or so on hatching are only *Ommastrephes sloani pacificus* besides *Watasenia scintillans*, moreover the former lay adhesive eggs. Consequently, in autumn, the larger number of larvae compared with the relatively small number of eggs is supposed to be derived from the larvae hatched out of adhesive eggs.

And of various species of squids caught by fishermen in the Japan Sea, *Ommastrephes sloani pacificus* holds the absolute majority in weight. Around Tsushima Islands they spawn already in October (Hayashi & Iizuka, 1953), then around Yamato-Tai Bank situated in the center of the Japan Sea the authors caught female *Ommastrephes sloani pacificus* with spermatophore in August, 1956, and on the west coast of Hokkaido the period from autumn to winter is the spawning season of the same species (Soeda, 1956). These facts should be evidence that the larger number of squid larvae in autumn originates in the spawning by "surume ika". The above stated seems to refer to the fact that in frequency distribution of dorsal length of mantle, larvae over 3 mm., especially mainly over 6 mm., are caught all at once

from November on.

iii) As no the smallest larvae of *Watasenia scintillans* are obtained even in spring, the best season in Toyama Bay, there is every reason to believe that, as soon as laid out, *Watasenia* eggs will sink to the depths of the sea.

7 Summary

1) This study deals with the seasonal and geographical distribution of pelagic squid eggs and larvae in the warm Tsushima Current regions along the west coast of Honshu. It is based on the results of the authors' analysis of 972 materials collected by the towings of "maru-chi" net at the seasurface the period January～December, 1955.

2) According to all the former studies, the squid corroborated to lay pelagic eggs is *Watasenia scintillans* (Berry) alone. Eggs dealt in this study are estimated to be that of *Watasenia scintillans* or its consanguineous species.

3) The occurrence period of pelagic squid-eggs extends from March to August, forming a peak in May. They occur ealier in the northern region than in the southern

4) The main occurrence regions in the Japan Sea are Toyama Bay, Wakasa Bay, the region from Hyogo Pref. to Shimane pref. and Keishō North along the east coast of Korea. But it may be sure that their distribbution overspread widely in the Japan Sea, not only in the warm Tsushima Current but in the cold Liman Current regions across the Liman Front if they are, to any extent, affected by the warm Tsushima Current.

5) The occurrence season of pelagic squid eggs in Toyama Bay coincides well with the season when adult *Watasenia scillans* move on toward the shore, namely the fishing season by settled nets for them.

6) Squid larvae are collected, except March, all the year around. But it is estimated that those squid larvae consist of various species of Decaqoda, judging from their occurrence periods, body sizes and morphological characters, etc..

7) Squid eggs occur, in the Japan Sea, within the limits between 10°C. and 27°C., especially between 15°C. and 18°C., then between 17.5 Cl‰ and 19.3 Cl‰.

Squid larvae are obtained only in the range from 9° to 27°C., especially 14°～19°C, and 24°～27°C.. The chlorinity range is 16.0‰～19.3‰; there is no best range unlike in water temperature.

8) This study also treat of spawning seasons of squids from some angles. For the future further studies are required, at all events.

8 Literature

1. Hayashi, S. and S. Iizuka. (1953). Studies on the early larval stages of "Surume-ika", *Ommastrephes sloani pacificus* (Steenstrup) — I. II. *Bull. Fac. Fish. Nagasaki Univ.* **1**. In Japanese.
2. Japan Sea Reg. Fish. Res. Lab. (1955). Soko uo shigen chosa yoho (Outline of the fisheries biological survey of bottom fishes, September 1954~May 1955.) **7**. Mimeographed. In Japanese.
3. Matsuno, S. (1915). Age of *Watasenia scintillans* (Berry) and its artificial fertilization. *Zoolog. Mag.* **27**(317). In Japanese.
4. Nishikawa, T. (1906a). Eggs of Rossia. *Zoolog. Mag.* **18**(212) In Japanese.
5. ——— (1906b). On a pelagic Cephalopoda egg. *Zoolog. Mag.* **18**(218). In Japanese.
6. Sasaki, M. (1913). Ecology of *Watasenia scintillans* (Berry). *Zoolog. Mag.* **25**(302). In Japanese.
7. Shimomura, T. (1957). Geographical Distribution of larval fishes, Decapoda, Arthropoda, and various eggs in the Japan Sea in August 1955. *Bull. Japan Sea Reg. Fish. Res. Lab.* **6**. In English.
8. Soeda, J. (1956). Studies on the ecology and the breeding habits of the squid, *Ommastrephes sloani pacificus* (Steenstrup). *Bull. Hokkaido Reg. Fish. Res. Lab.* **14**. In Japanese.
9. Yamamoto, T. (1942). Embryonal development of *Sepia esculenta* Hoyle. *Botany and Zoology.* **10**(2). Yokendo, In Japanese.
10. ——— (1943). Squids and Octopus. *Kaiyo no Kagaku.* **3**(10). In Japanese.

Geographical distribution of squid eggs in the Japan Sea, during the year of 1955. (Figs. 1～13).

○ : the position of station towed but no egg was obtained.

● : the position of station, at which eggs were obtained.

Arabic numerals at the sations designate the number of squid eggs and those on land designate the towing period in each month.

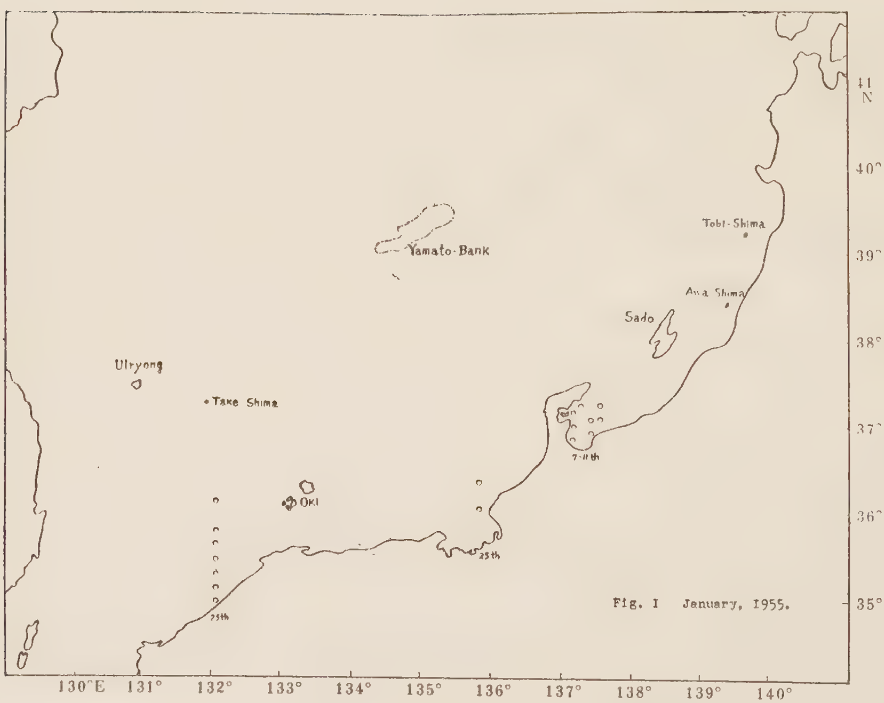


Fig. I　January, 1955.

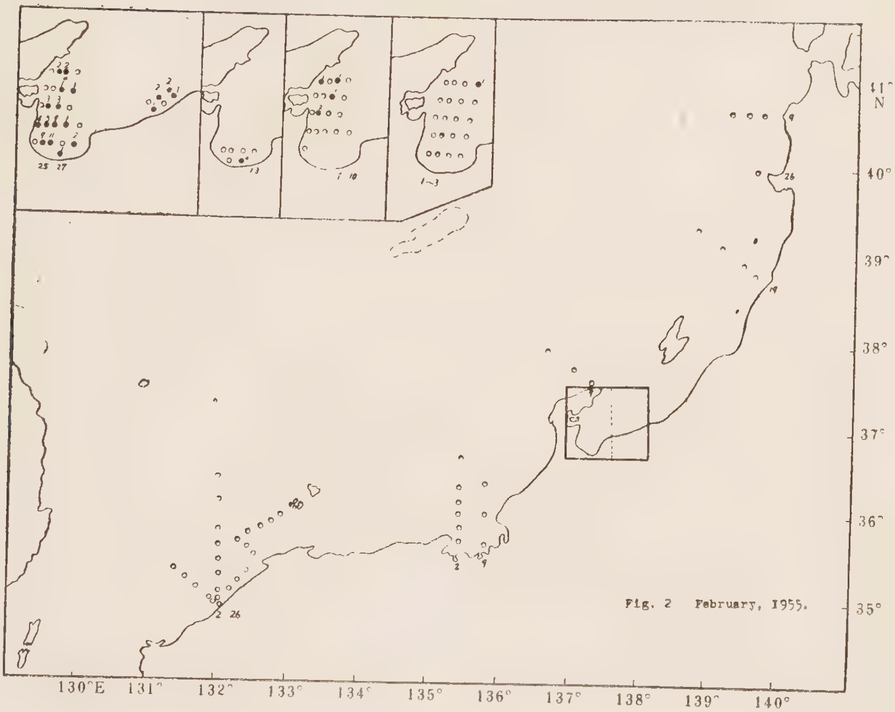


Fig. 2 February, 1955.

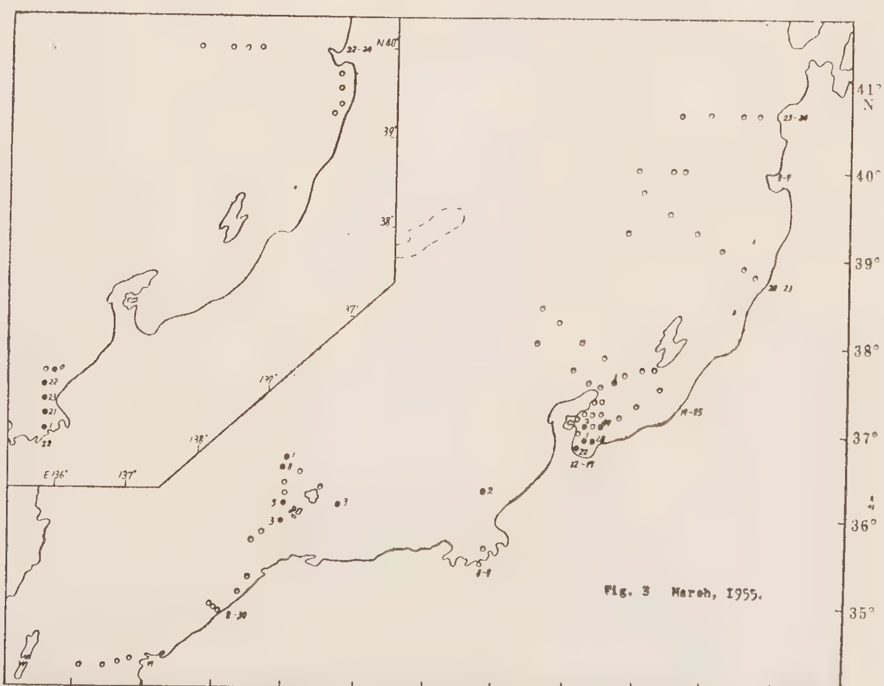


Fig. 3 March, 1955.

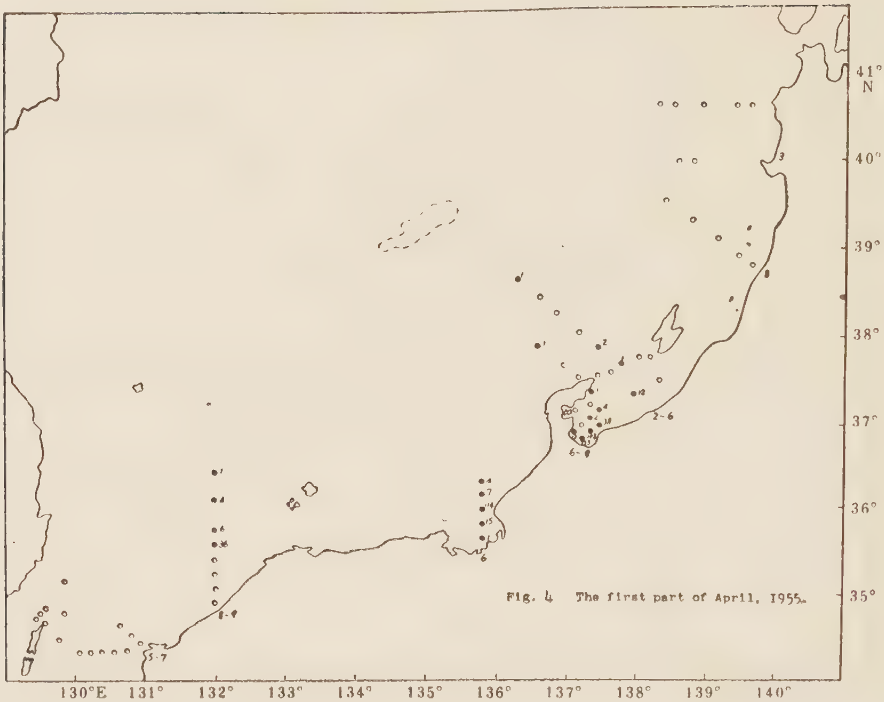


Fig. 4　The first part of April, 1955.

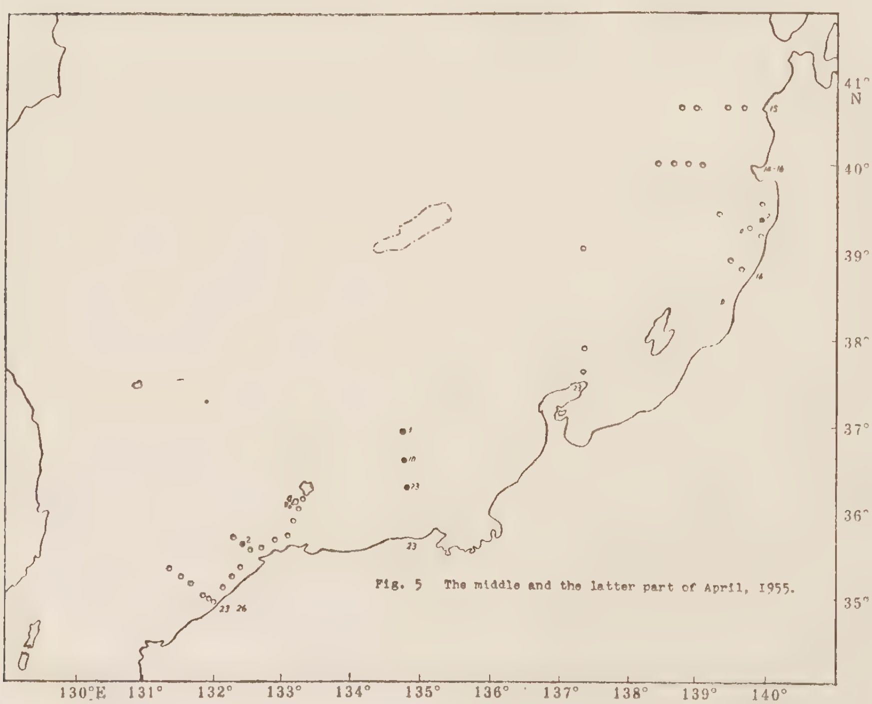


Fig. 5　The middle and the latter part of April, 1955.

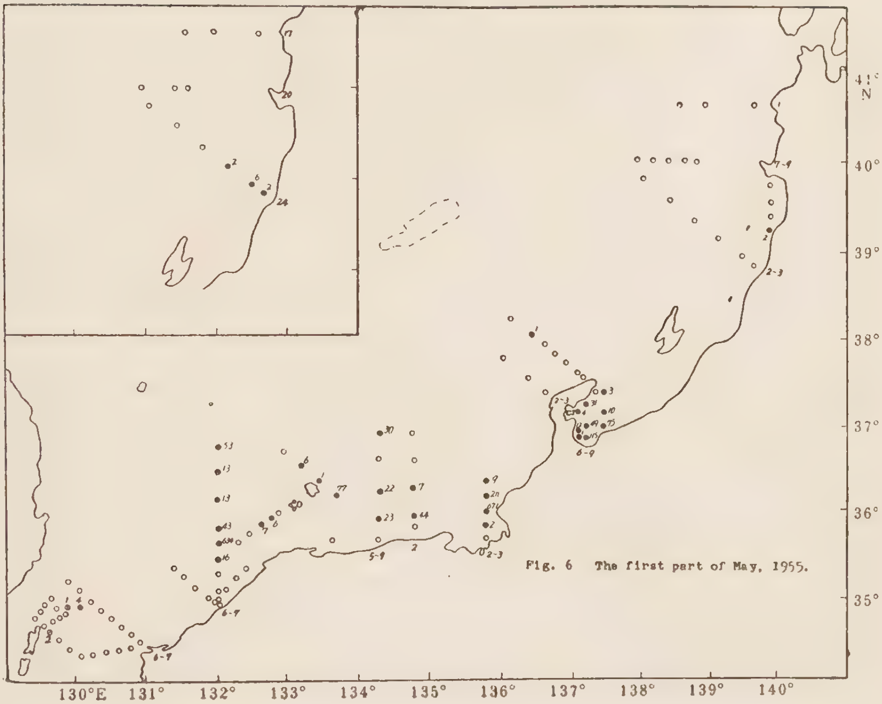


Fig. 6 The first part of May, 1955.

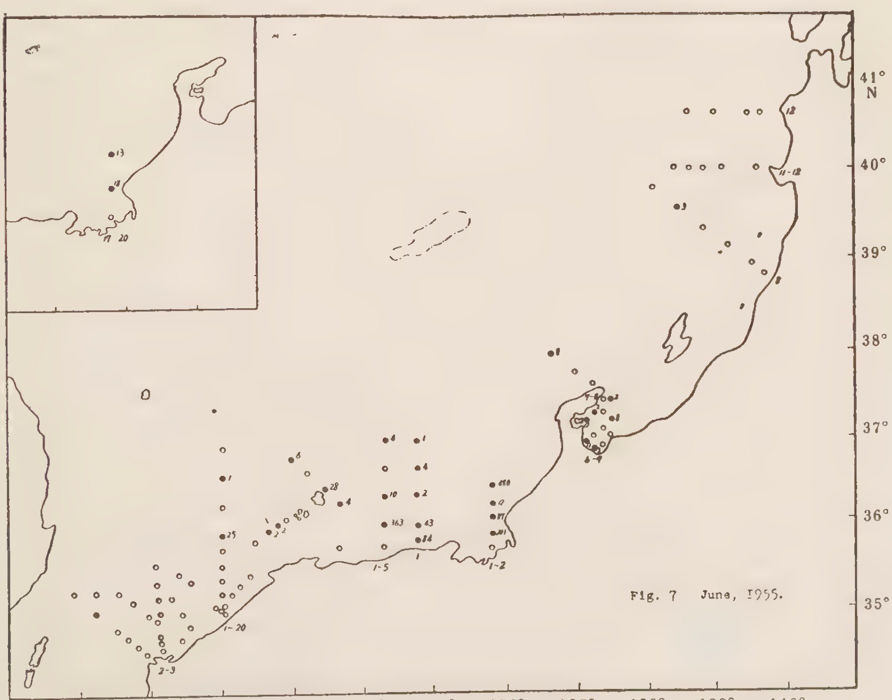


Fig. 7 June, 1955.

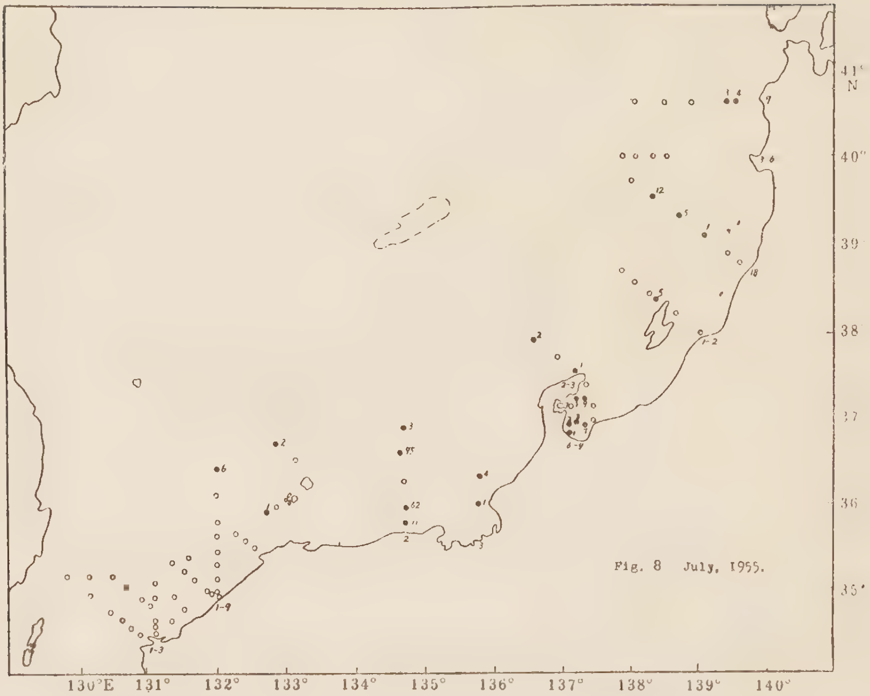


Fig. 8 July, 1955.

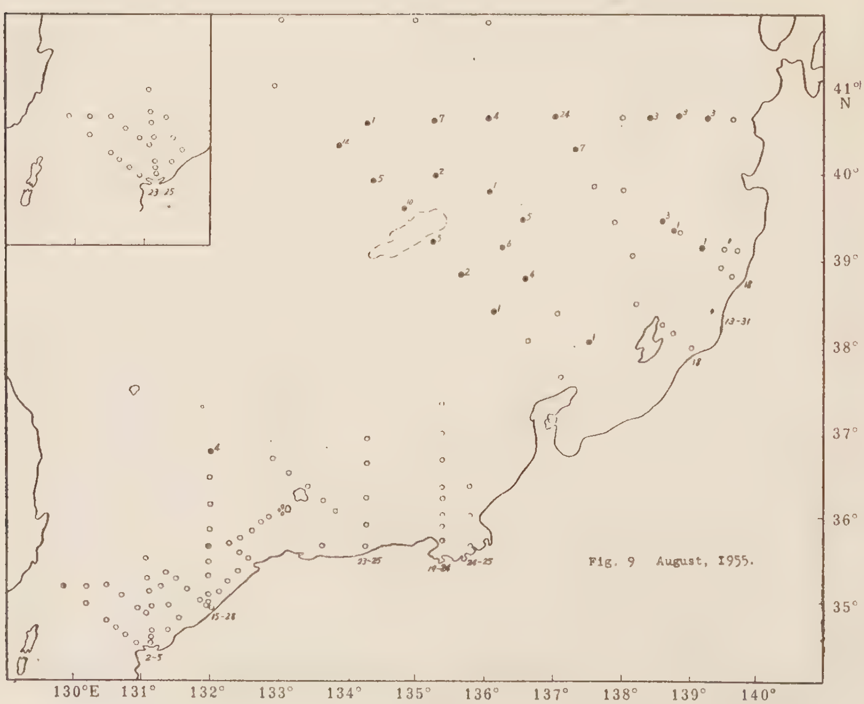


Fig. 9 August, 1955.

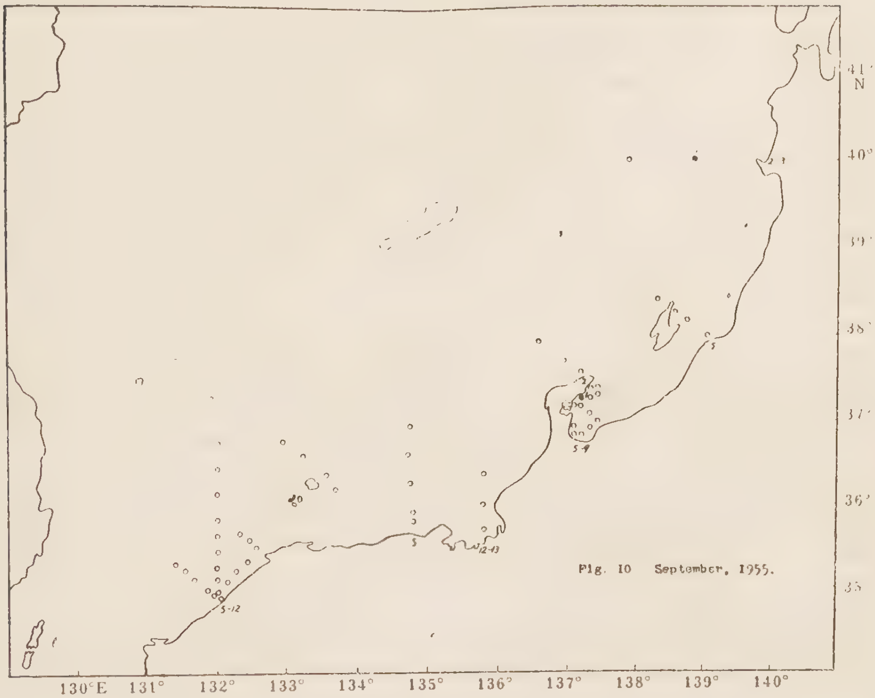


Fig. 10 September, 1955.

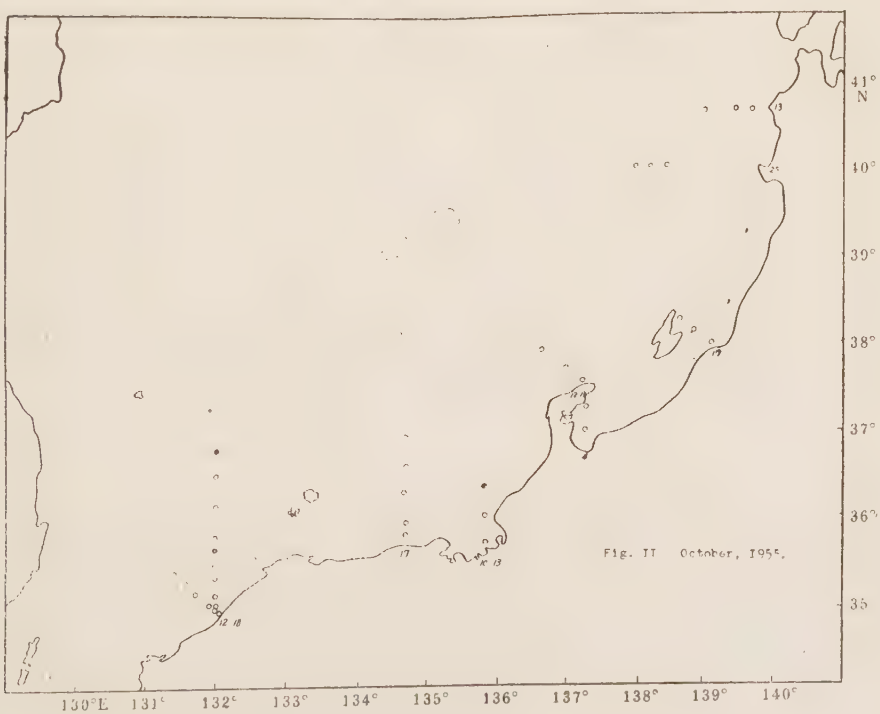


Fig. 11 October, 1955.

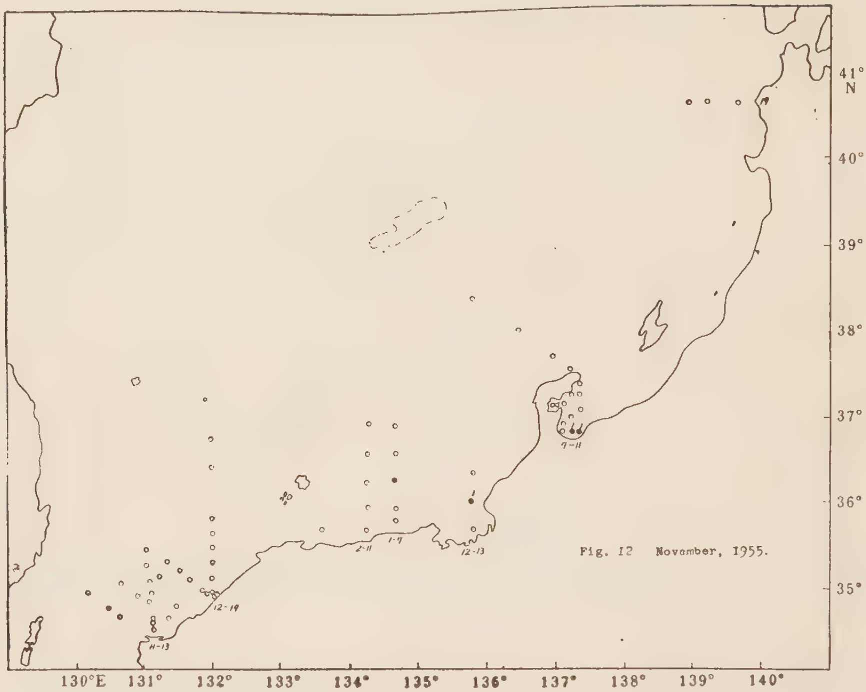


Fig. 12　November, 1955.

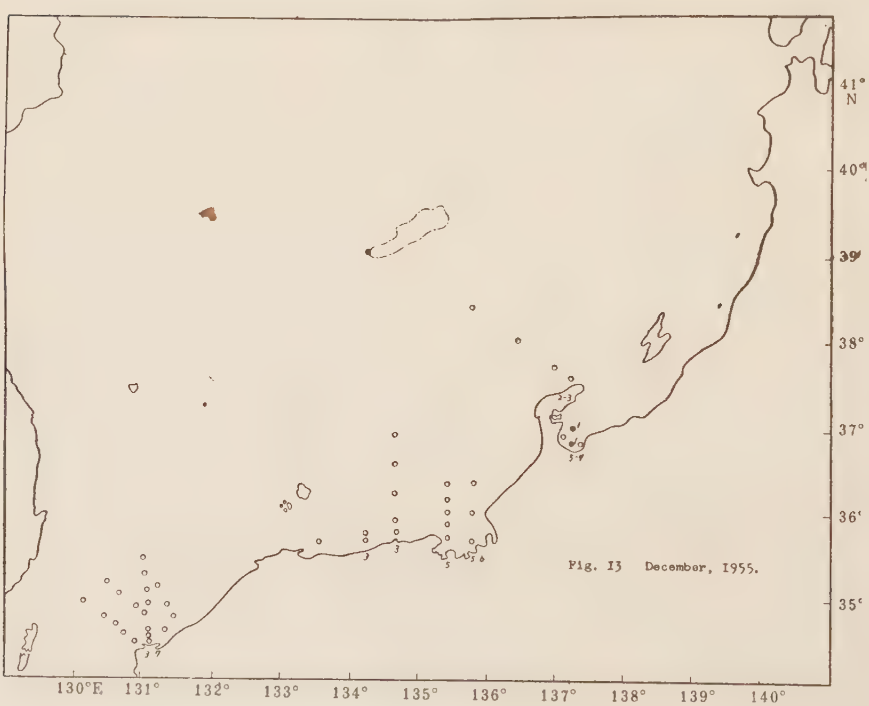


Fig. 13　December, 1955.

能登半島西岸の夏定置網漁況について

永　田　俊　一

On the Fishing Conditions of Summer Set-Net on the Western Coast of Noto Peninsula.

by

Shunchi NAGATA,

Abstract

A number of large scale set-nets have been built during every May through July around the coast of Noto Peninsula.

Some considerations are made concerning the fishing conditions, during the period from 1921 through 1955, of Saikai No.1 set-net which has been built on the western coast of Noto Peninsula; and the fhe following results are obtained.

1) As for blue fin tuna (*Thynnus thynnus*), flying fish (*Cypselurus agoo*), and frigate mackerel (*Auxis thazard*), close connections can be seen between catches and hydrographic conditions & the dates of their first landings, e.g., good catches seem to appear in years when the water temperature of the Tsushima Current is high, and when the first date of their landings is earlier.

2) The mode in weight compositions of blue fin tuna tends to move its position at a rate of five kan per annum (1 kan=3.75kg.), and the annual catch show in number is good when the mode is placed ten to thirty Kan.

Ⅰ　緒　　言

日本海の夏定置網は4月より7月までを漁期とし沿岸各地に浮設されるが好漁場としては山口，島根の沿岸，若狭湾北東部，能登半島周辺，佐渡ケ島，男鹿半島，津軽半島南西部沿岸の６ケ所があげられる。しかして能登半島周辺では５月より７月までを漁期として日本海側ではブリを主体にマグロ，トビウオ，ソーダカツオ，サバ等を，富山湾側ではマグロ，タイ，サバ，中小アジ，トビウオ等を目的に夏網と称せられる大型定置網が20ケ統近く浮設されるがなかでも屈指の好漁場と云われる能登半島西岸，西海１号定置網の大正10年より昭和30年にいたる過去35ケ年間の漁況について調査したのでその結果を報告する。なお本調査にかんし種々便宜をはかつていただき，かつ資料を提供していただいた山寺敏之氏ならびに石川県水産試験場長菅野六郎氏にあつく感謝する次第である。

Ⅱ　漁場の概要

西海１号網は第１図に示すごとく日本海に面した能登半島西岸の富来湾内海士埼よりの水深35Mの所に浮設されている。がんらい西海夏定置網というのは１号網，２号網，３号網とそれに玄ノ釜の４ケ統を総称したものであるが３号網は昭和17年，玄ノ釜は昭和21年以来それぞれ浮設されておらず現在は１号網と２号網が操業されているのみである。そして２号網も昭和16年より18年まで操業を中止していたので結局大正時代より現在まで継続して浮設されているのは１号網だけである。なお図でもわかるごとく湾内には富来と福浦にそれぞれ大型の夏定置網が１ケ統ずつたてられているが福浦の網は最近操業を中止した。網は４月中に設置される事もあるが昭和20年以降は５月上旬より中旬にかけてたてられる事が多くなつた。（２号網は４月中に浮設され

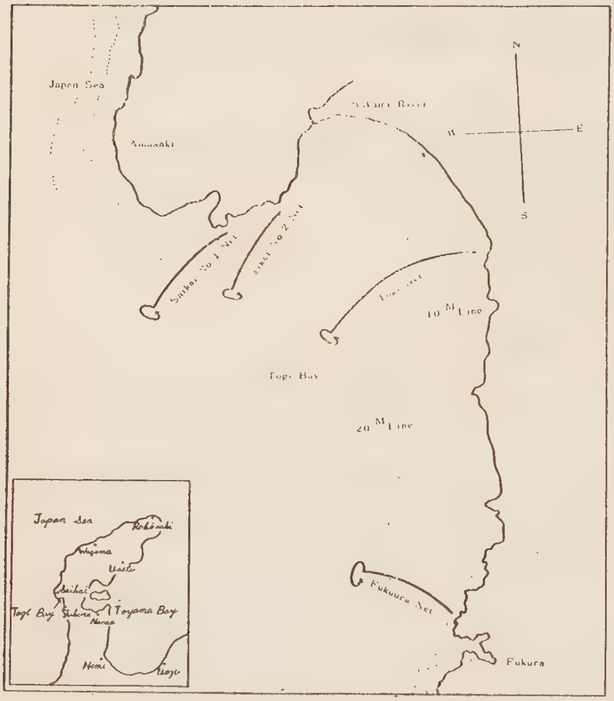


Fig. 1. Location of Saikai No.1 Set-net.

る)。盛漁期は5月下旬より7月上旬までで漁獲物のおもなものはブリを筆頭にマグロ，メジ，トビウオ，ソーダカツオ，サバ，タイ等である。

Ⅲ 漁況と海況

日本海では対馬海峡を通り日本海を北上する対馬暖流の強弱と，海底地形による湧昇流ならびに沖合冷水域の接岸状況などが漁況と密接な関係を有している事は周知の事実である。いま西海1号定置網の長期にわたる漁況の変動を海況上より考察するためには能登半島沖合と沿岸の両者の海況を明らかにしなければならないが，長期にわたる連続した沖合の海況資料が不足している現在においては沿岸海況のみから考察を加えてゆく方法しかなく，そのために沿岸定置観測の結果を沿岸海況のめやすとして使用した。また富来湾は能登半島西岸に位置し，禄剛埼よりややはなれているので定置観測の場所も富来湾の北方の禄剛埼と西方の経ヶ岬の2ヶ所を選定した。以上のような状況のもとに経ヶ岬と禄剛埼の大正10年より昭和30年までの夏網の漁期にあたる5月，6月，7月の各月の平均水温値を第2図に示し過去35ヶ年間の能登半島西岸における沿岸海況の推移について考察を加えると下記のごとくである。

1. 経　ヶ　岬

5　月

過去35ヶ年間の平均水温は16.2°Cである。大正10年より昭和13年まではがいして平均以上の水温が続き，特に昭和3年より8年までは高温であつた。昭和14年から22年までは平均以下の年が多くこの間は低温に経過した。昭和23年以後も平均以下の年が多いが水温はたかめに推移している。

6　月

平均水温は19.6°Cである。大正11年の水温は高かつたがその後降温の傾向がみられ大正15年まで続いた。昭和2年より水温は上昇し昭和17年まで大体高温に経過したが特に昭和4年から8年までは高温であつた。昭和18年より27年までは平均以下の水温が続きいわゆる低温時代を形成した。28年からはがいして高温に経過している。

7　月

平均水温は23.6°Cである。大正10年より15までは平均水温より高い年もあるが低温に経過した。昭和2年より15年までは水温もたかめに推移し特に昭和2年より9年までは高温であつた，昭和16年より29年までは逆に平均以下の年が多く低温が続いた。

以上経ヶ岬における5月，6月，7月の水温の推移状況をのべたがこれを綜合して考察すると大正10年より15年まではめだつてはいないが，やや低温に経過した傾向がうかがえる。昭和2年から水温は上昇の傾向をたどり15年までは高温であつたがなかでも昭和3年から8年まではいちぢるしかつた，その後昭和18年より27年までは低温に推移したが28年以後はわずかながら上昇の傾向がみられる。

2. 禄　剛　埼

5　月

過去35年間の平均水温は経ケ岬より1.4°C低い14.8°Cである。大正10年より14年までの水温は平均以下の年が多かつたが大正15年より上昇の傾向をみせ昭和16年までは高温が続いた。その後昭和17年より水温はひくめに移行し昭和20年から27年までは平均以上の年もみられるが低温に経過した。昭和28年以降は昇温の傾向にある。

6　月

平均水温は19.0°Cである。大正10年より15年までは11年が高温であつた以外は平均以下の年が多かつた。昭和2年より水温はたかめに推移し16年までは高温であつた。その後昭和17年より水温はひくめに移行し25年までは低温が続いた。26年以降はやや高温に経過している。

7　月

平均水温は23.3°Cである。大正10年より15年までは高温の年もあるがいして低温に経過した。昭和2年より水温はたかめに推移し15年までは高温であつた。その後昭和18年からはひくめに経過し大体29年までその現象がみられる。

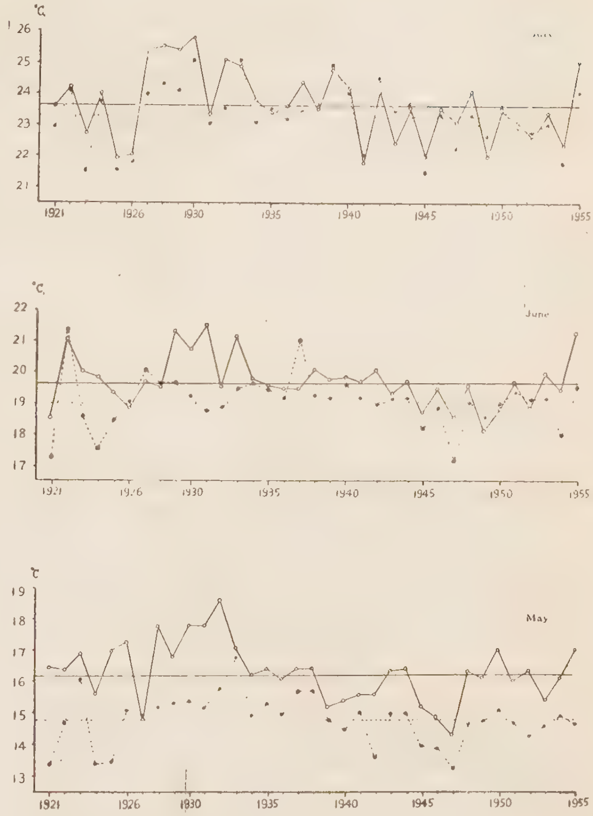


Fig. 2. Monthy maen surface water temperature at Rokugo Saki (•······•) and Kyo-ga Misaki (○——○)

For signs and explanation see text

以上禄剛埼における過去35ケ年間の5月，6月，7月の水温の推移状況についてのべたがこの3ケ月間の海況状況を綜合して考察すると下記のごとくである。すなわち大正10年より15年までの水温は平均以下の年が多く低温であつたが，昭和2年から水温は上昇し16年までは平均以上の年が多く高温であつた。その後昭和17年から水温はひくめに移行し昭和20年より27年までは低温であつた。

以上経ケ岬と禄剛埼の過去35ケ年間にわたる沿岸水温の推移状況を考察したが，これを基本に能登西岸の沿岸海況を綜合的にみると大正10より15年まではやや低温の時代，昭和2年から16年までは高温時代，昭和19年より27年までは低温時代，それ以後は昇温の傾向にある時代というように大別できる。つぎにマグロ，メジ，トビウオ，ソーダカツオの大正10年より昭和30年までの漁獲高を第3図より第6図に示し海況との関係についてみると下記のごとくである。

3.　マ　グ　ロ

当地方でマグロといわれているのは体重3貫以上のクロマグロ（*Thynnus thynnus*）でそのなかでも10貫以下を小マグロ，10貫から30貫位までを中マグロ，それ以上を大マグロと称し3段階に区別している。入網の最も多い時期は6月中旬より7月中旬までであるが初漁（1ビ以上）は30貫以上の大マグロがほとんどで時期は5月下旬が多い。そして30貫以上の大マグロは中，小マグロにくらべ一般に入網時期が早い。魚体の最大は昭和24年に漁獲された80貫のものである。

第3図よりみると大正10年より15年までの低温時代は大正11年に90ビちかく漁獲されたのが最大で全般的に

※　トビウオは大正11年より漁獲が記載されている。

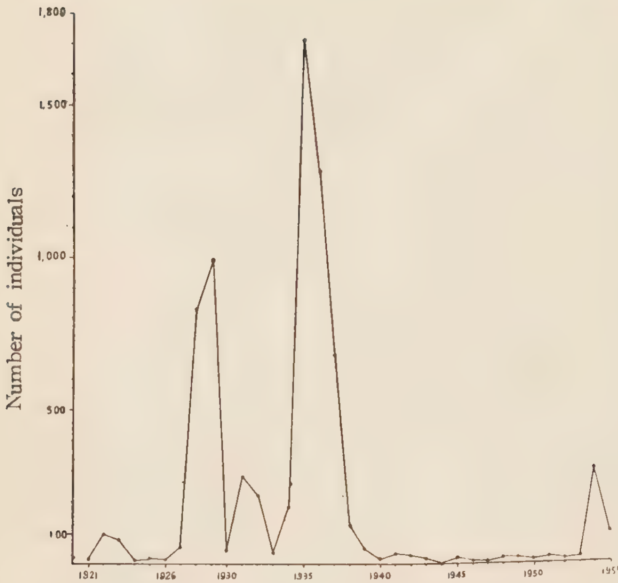


Fig. 3. The annual catch of blue fin tuna in the Saikai No.1 Set-net.

は不漁であつた。それが昭和3年より漁況は好転し昭和5年，8年に不漁がみられるが全般的には13年まで好漁が続き，特に昭和3年，4年，10年，11年，12年は豊漁であつた。海況よりみるとこの時期は高温時代にあたる。昭和15年以降になると再び漁獲は減少し，低温時代は20ビ以上の漁獲はみられず非常に不漁であつた。昇温傾向にある昭和29年以降の漁獲は良好で昭和31年も好漁であつた。以上の結果からみるとマグロの来遊は海況と密接な関係があり，その漁況は全般的にみて高温時代は好漁，低温時代は不漁という事がいいうるようである。

4. メ　ジ

当地方でメジというのは仔マグロの事で大体2貫以下のクロマグロを称し，別名をヨコワまたはシビとも云う。漁期は5月から6月までで7月になるとほとんど入網はみられなくなる。魚体は600～900匁のものが大部分で400匁以下，1貫以上のものはごくわずかである。第4図の漁獲高よりみると大正10年より15年までの低温時代には1,000 ビ以上の入網はみられず不漁であつた。それが昭和2年より漁況が好転し3年，4年，11年に不漁もみられるが高温時代のおわる昭和18年までは大体好漁であつた。その後昭和19年より漁獲はふたたび減少し，28年までの低温時代は26年に好漁もみられるが不漁が続き特に昭和20年から24年にいたる5ケ年間は凶漁であつた。昭和29年以降の漁獲は良好である。以上の結果より考察するとメジの漁獲は高温時代は好漁，低温時代には不漁という傾向が強くあらわれている。

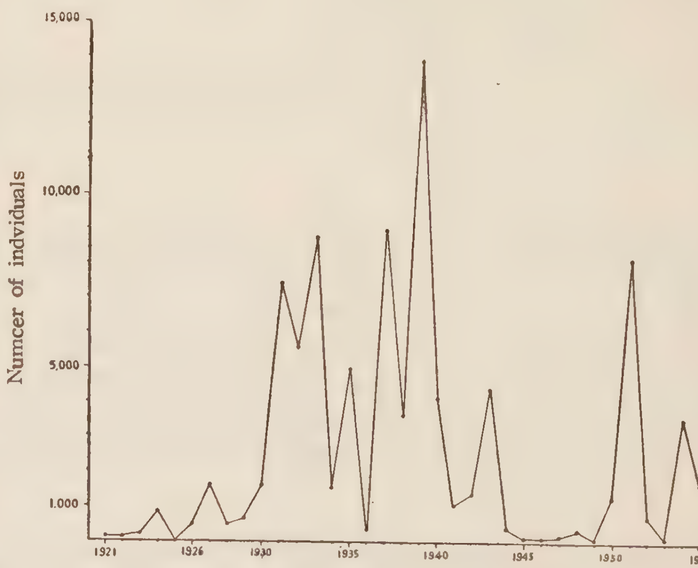


Fig. 4. The annual catch of small type blue fin tuna in the Saikai No.1 Set- net.

5. ト　ビ　ウ　オ

当地方でトビウオと称するのは大部分がツクシトビウオ (*Cypselurus heterurus döderleini*) で魚体のやや大きいものを別名「角トビ」と呼んで小さいものと区別している。漁期は5月下旬から7月上旬頃までであるが7

月に入ると漁獲は急減する。魚体は25匁から40匁までのものが漁獲の95%をしめ，そのなかでも魚体の大きい35匁から40匁のものは漁期のはじめに入網し，漁期が進むにしたがつて小型のものに移つてゆく傾向が強くみられる。又昭和16年には約1,000ビ，23年には2ビ，28年には200ビと例年にはみられない70～90匁の超大型のものがいずれも5月の漁期のごくはじめに漁獲された事が記載されてあるがこれは魚種が異るのではないかとおもわれる。

第5図の漁獲高よりみると低温時代の大正11年より14年の間は40,000ビ以上の漁獲はなく入網も7月に多くて不漁であつた。大正15年より漁況は好転し高温時代の昭和2年より15年までは昭和7年のような不漁の年もみられるが全般には好漁で漁獲も6月に多かつた。昭和16年から25年までは昭和23年に好漁があつたが低温時代にあたり不漁が続いた。昭和26年以降の漁獲は大体40,000ビ程でやや好転し現在にいたつている。

以上の結果よりみるとトビウオもやはり昭和のはじめから15年頃までの高温時代には好漁，昭和20年を頂点とした低温時代には不漁と云う傾向が強くみられ，低温時代は7月に，高温時代は6月に漁獲が多いようである。

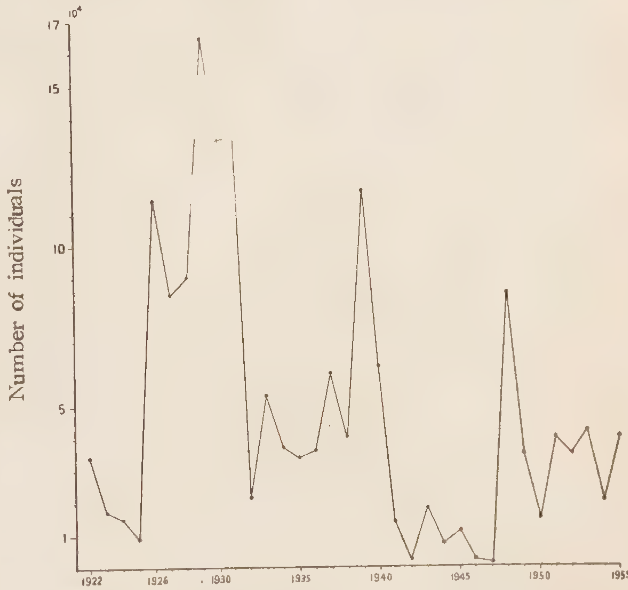


Fig. 5. The annual catch of flying fish in the Saikai No.1 Set-net.

6. ソウダカツオ

当地方では一般にカツオと称せられ魚体は120匁から150匁のものが多く，100匁以下のものはときおり入網をみる事もあるが200匁以上のものは漁獲されていない。昭和12年から漁獲されたもののなかで最も大きな魚体は195匁のものである。漁期は7月以降で網をきりあげる時まで漁獲される。この魚もトビウオと同様漁期のはじめに140匁以上の大型のものが来游し，漁期が進むにしたがつて魚体は小さくなり8月に入ると120匁以下のものが多くなる。

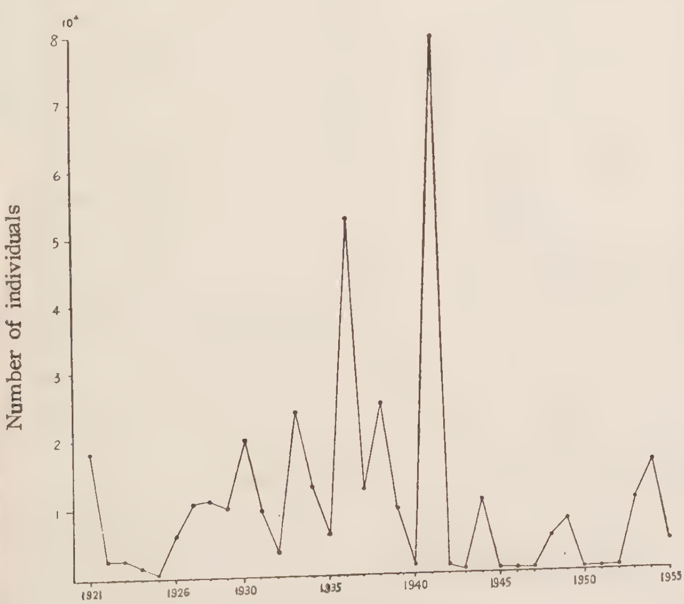


Fig.6. The annual catch of frigate mackerel in the Saikai No.1 Set-net.

第6図よりみると大正10年より15年までの低温時代は，大正10年がやや好漁のほかはいずれも10,000ビ以下で漁獲高はかんばしくない。昭和2年より漁獲は好転し7年，10年，15年に不漁がみられるが16年までは

全般に好漁が続きこの期間は高温時代にあたつている。その後昭和17年より漁獲は不振となり27年までの低温時代は不漁であつた。昭和28年以降の漁獲はやや好転の傾向をみせている。すなわちソーダカツオの漁獲高は不漁の年もみられるが高温時代は全般的にみて好漁，低温時代は不漁と云う事が云いうるようである。しかし網が漁期なかばにしてきりあがる事もありしたがつて漁獲高について充分な考察が加えられない年も考えられるので，この点は充分考慮する必要がある。

以上西海1号定置網に入網するマグロ，メジ，トビウオ，ソーダカツオのそのおのおのの漁況と海況の関係について述べてきたが，これを綜合して考察すると能登西岸の夏定置網に入網するこれら魚族の漁況は，年により異なる事もあるが大体において高温時代は好漁，低温時代は不漁と云う結果が強くあらわれており，漁況と海況との間には密接な関係が認められる。つぎに上記の結果はぞくに暖流系魚族とよばれるものについてのみ考察を加えてあるのでそれと対照の意味をもつて，マスの昭和2年より30年までの漁獲高を第7図に示し，その漁況と海況との関係について一応の検討を加えた。がんらい西海1号定置網は既述した魚族を漁獲の対象にしているので，網は5月の上旬から中旬にかけて浮設される事が多い。しかして当地方のマスの漁期は3月から4月で5月に入ると漁獲も急減し，しかも10日以後になるとほとんど定置網には入網をみなくなるので，その結果網を4月にたてた場合と5月でも早く浮設した時とおそい時では漁獲条件が必然的に異なつてくる。それ故第7図に示した漁獲高も5月のもののみとし，浮設時期と云う重要な要素を充分考慮に入れて考察を加えた。なお当地方の定置網に漁獲されるマスはサクラマス（*Oncorhynchus masou*）が多く，200匁から1貫匁のものが主として入網し，そのなかでも300匁から500匁のものが最も多い。

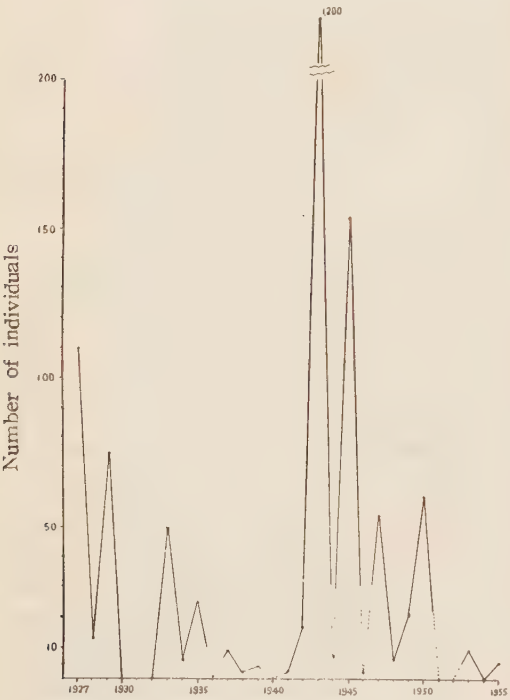


Fig.7. The annual catch of cherry salmon in the Saikai No.1 Set-net.

—•—: Nunber of individuals in years, When the Net was settled before May 9.

…•…: Number of individuals in years, when the Net was settled after May 10.

すなわち昭和2年から16年までの高温時代に漁獲が多かつたのは2年，4年，8年で他の年は少く全般的にみると漁況は悪く5年から7年にかけては4月ないし5月のはじめに網がたてられているにもかかわらず漁獲は皆無であつた。しかし昭和2年，4年は5月20日頃まで漁獲があり10日以後でも1日20ビ程度の入網をみた日がある。11年，15年は5月10日以後に網がたてられている。

低温時代に入ると昭和18年に大漁がみられ20年，22年，25年も漁獲が多かつた。昭和19年，21年，26年，27年は5月10日以後本格的操業にかかつている。昭和28年以降の漁獲高は少く，ことに29年は4月下旬に網がたてられているにもかかわらず網獲は皆無であつた。

以上のような状況からみるとマスの漁獲は高温時代より低温時代の方が良好な傾向があらわれているが，なにぶんにも低温時代に5月10日以後操業された年が4回もあり高温時代にも昭和2年，4年のごとき好漁がみられるので上記の傾向はかんたんにはうんぬんできない。なお第7図も5月だけの水揚高をとつたので全般にマスの漁獲高が非常に少ないと云う事と，したがつて50ビ以上の漁獲が必然的に好漁の部類に入ると云う現象がでてくるので漁況それ自体に不備な点が多いと云う事も充分考えなければならない。

以上のほかに昭和19年から22年にかけてホケツの入網が多かつた事も附記しておく。

Ⅳ 初漁日と漁況海況

日本海の一般漁業においては対象とする魚族の来游が早い年は普通好漁だと云われ，初漁日の遅速は非常に重要視されている。いま西海1号定置網で漁獲される重要魚種のうち比較的魚体差が少なく，かつまとまつて入網するメジ，トビウオ，ソーダカツオについてその初漁日を第8図に示し漁況と海況との関係について考察すると下記のごとくである。この場合1日にメジは5ビ以上，トビウオは50ビ以上，ソーダカツオは20ビ以上入網した場合を初漁日とした。

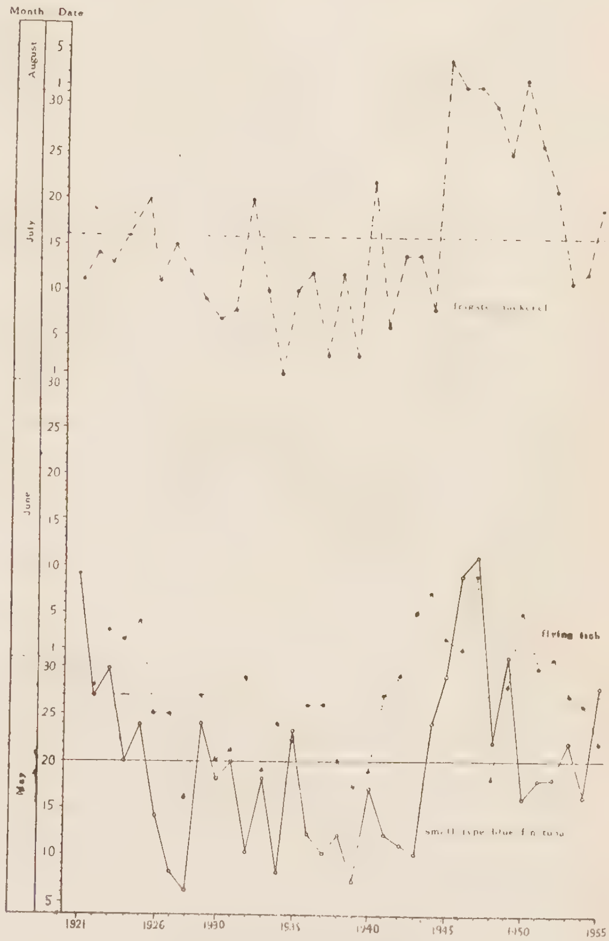


Fig. 8. Yearly fluctuations in the date of fhe first landnig of flying fish, small type blue fin tuna, and frigate mackerel.

For signs and explanation see text

1. メ　　ジ

過去35ヶ年間の初漁日の平均は5月20日で最も早いのは昭和3年の5月6日，最も遅いのは昭和22年の6月11日で両者の日数の差は約35日におよんでいる。低温時代の大正10年から15年にかけての初漁日は大正15年が平均日より早いだけで全般におそく漁獲高もよくない。高温時代の昭和2年から18年までは昭和4年と10年の初漁日が平均日よりおそいだけでその他の年は早く漁獲高も良好である。低温時代の昭和19年より27年までは漁獲高のやや良好であつた昭和25年，26年，27年の初漁日は早くあらわれているが，その他の年はいずれもおそく漁獲もきわめて不振である。昭和28年以降は29年が平均日より早く28年，30年はおそいと云う結果になつている。

以上の状況から考察するとメジの初漁日は全般的にみて高温時代には早く，低温時代にはおそくあらわれ漁獲高も早くあらわれた年は良好であるが，おそくあらわれた年は不漁の傾向が強い。すなわち初漁日の遅速と漁獲高ならびに海況との間には密接な関係があると云う事が云いうる。

2. ト　ビ　ウ　オ

初漁日の平均はメジよりややおそく5月27日である。最も早いのは昭和3年の5月16日，最もおそいのは昭和22年の6月9日でその差は24日である。大正11年より14年までの初漁日は平均日よりおそく漁況も不振で低温であつた。大正15年より初漁日は早くなり昭和7年に一度おそかつたが15年までは平均日より早く，この時代は漁獲もよく高温期である。昭和7年の初漁日のおくれた年の漁獲は不振である。昭和16年から25年までは昭和23年に早い年がみられるだけで他の年はいずれも平均日よりおそくこの期間は低温時代にあたり漁獲も悪い。なお23年の初漁日が早かつた年は漁獲高も良好である，26年以降の初漁日は漸次早くなつてきており漁獲

も好転している。

以上の結果よりみると初漁日が早くあらわれた年は全般に漁獲は良好であるが，おそい年は不漁でかつ高温時代には初漁日は早く低温時代はおそくあらわれる傾向が強い。すなわちトビウオの初漁日の遅速と漁獲高ならびに海況との間には密接な関係がある事が認められた。

3. ソーダカツオ

初漁日の平均は前2魚種にくらべいちぢるしくおそく7月16日である。最もはやかつたのは昭和9年の7月1日，おそかつたのは昭和20年の8月4日でその差は1ケ月以上におよんでいる。低温時代の大正10年より15年までの初漁日は概しておそいが平均日よりはやくあらわれている年が多い。しかし漁獲は大正15年をのぞきかんばしくない。昭和2年から16年までの初漁日は7年，15年にそれぞれ平均日よりおそい年もあらわれているがその他の年ははやく，この期間は漁獲も良好で高温時代にあたつている。なお初魚日のおそい昭和7年，15年の漁獲は良好でなかつた。その後昭和17年より初漁日はおそくなり特に昭和20年より27年までの間は平均日よりいちぢるしくおそく，この期間において10,000ビ以上の漁獲はなく海況も低温に経過した，昭和28年以降の初漁日ははやい傾向にあり漁獲も好転している。

以上の結果よりみるとソーダカツオの初漁日の遅速と漁獲高ならびに海況との間には密接な関係が認められ高温時代には全般的に初漁日ははやく，低温時代にはおそい状況がみられる。又漁獲高も初漁日のはやい年は好漁おそい年は不漁の傾向が強い。

以上メジ，トビウオ，ソーダカツオの3魚種のおのおのの初漁日の遅速と漁況海況との関係について述べたが，これら3魚種においては高温時代には一般に初漁日がはやくあらわれ漁獲も良好であるが，低温時代は反対に初漁日がおそく不漁であると云う傾向が強く認められる。そして高温時代でも初漁日がおくれるとその年の漁況はおもわしくない場合が多く，低温時代でも初漁日がはやいと漁況は良好である場合が多い。このように初漁日は海況漁況と密接な関係をゆうしているので上記の3魚種においては初漁日の遅速は漁況予察上重要な意味をもつものと云えよう。

V　マグロ体重組成と漁況

日本海のクロマグロの魚体については漁撈試験のさい測定された値が断片的に記載されてあるのみで詳細に調査されたものは現在みあたらない。第9図に示す体重組成の値も精密に測定したものではなく水揚後販売にあたつて一本ずつ計量されたものである。したがつて100匁程度の誤差はまぬがれないが魚体組成の変化をみるためにはさしつかえないと思う。第9図に昭和9年より30年までのマグロの体重組成を対数値をもつて示し，その累年変化について考察すると下記のごとくである。すなわち昭和9年には14～15貫のものが最も多く入網し，12～16貫のところに漁獲の山があらわれているが，翌10年には16～17貫のものが最も多く入網し16～19貫のところに山が移行すると同時に25貫のところにも単独に小さな山があらわれている。そして11年には20～25貫，12年には25～31貫のところにそれぞれ漁獲の山がみられる。昭和13年の山はあきらかでないが14年には35～40貫のところに小さな山があらわれている。昭和15年になると1～3貫のところに山があらわれそれが16年の8～9貫の小さな山をへて，昭和17年には10～13貫のところに移つている傾向がみられるが，なにぶんにもこの時代は低温時代に移行する時でマグロの漁獲も非常に少なく明確な事は判明しない。その後昭和19年より26年まではまとまつた入網はみられず，したがつて漁獲の山も小さく判然とした結果はでてこない。なお昭和9年より14年にかけて50貫のところに毎年単独に小さな漁獲の山があらわれている。昭和27年にいたり小さいが2～5貫のところに漁獲の山があらわれているが，28年をへて29年には大きくなつて12～15貫のところに移行し，30年には17～21貫のところに漁獲の山がみられる。しかして31年は図示してないが日本海沿岸全般にわたり24～25貫のマグロが好漁であつた。

以上昭和9年より30年までのマグロの年別体重組成の変化について考察したがこれによると昭和9年から12年，昭和29年，30年においては漁獲の山が年毎に大体5貫ずつずれてあらわれている事が明瞭に認められ，その他の年においても上記の傾向は漠然的ではあるがみられる。しかして昭和9年から12年の好漁の場合は25～

※　昭和9年以前の資料には魚体は記入されていない。

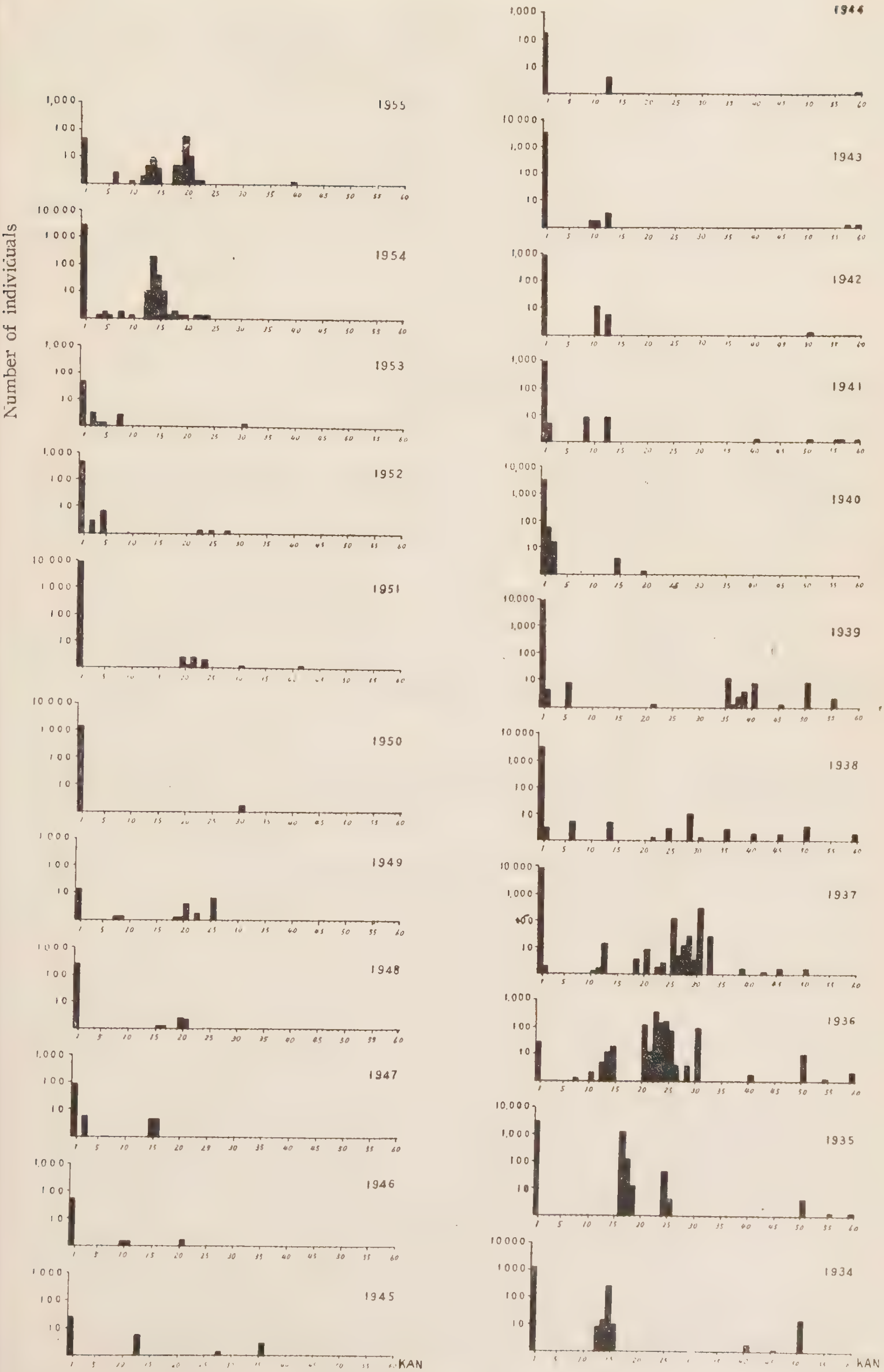


Fig. 9. Variation of body weight composition of blue fin tuna

30貫の漁獲の山を最後に濃群の入網は終つている。一方1貫以下の仔マグロ（メジ）の好漁な年，たとえば昭和12年，14年，15年，25年にはその翌年に1～5貫のところに小さな漁獲の山があらわれているが昭和21年，27年には漁獲が少なくても翌年には山があらわれている。このように能登半島西岸に来遊するマグロはその体重組成のモードがある一定の割合，すなわち年毎に大体5貫のはばをもつて移行する傾向が強くみられるのでそこに卓越群の存在する事が考えられる。そして高温時代に漁獲の山が10～15貫のところにあらわれそれが25～30貫のところに移行するまでは漁獲は良好であるが30貫以上になると濃群の来游は少なくなるようである。

すなわち昭和9年以降のクロマグロ体重組成や海況より考察すると能登半島西岸に来游するマグロは高温時代にしかも卓越した群があらわれ，その魚体が10～30貫にある場合に好漁がみられその他の場合にはあまり漁獲は期待できない結果がえられた。

Ⅵ 摘　　要

能登半島西岸の富来湾に設置されてある西海定置網の大正10年より昭和30年までの漁況を調査し，経ケ岬と禄剛埼の沿岸定置観測結果より能登半島西岸の海況の推移を考察してマグロ，メジ，トビウオ，ソーダカツオの漁況と海況，メジ，トビウオ，ソーダカツオの初漁日と漁況海況，マグロ体重組成と漁況との関係について述べた。

1　能登半島西岸の5月，6月，7月の沿岸海況は経ケ岬と禄剛埼の沿岸定置観測結果より考察すると，大正10年より15年まではやや低温，昭和2年より16年までは高温，昭和19年より26年までは低温に経過した。

2　マグロ，メジ，トビウオ，ソーダカツオの漁況は高温時代は好漁，低温時代は不漁の傾向が明瞭に認められた。

3　メジ，トビウオ，ソーダカツオの初漁日の遅速は漁況海況と密接な関係をゆうし，高温時代には初漁日も一般にはやく好漁であるが，低温時代は逆の現象がみられ漁況も低調である事が認められた。

4　マグロの漁獲の山は年毎に大体5貫のはばをもつて移行し，高温時代にあらわれた卓越群とおもわれるものの魚体が10～30貫にある場合に漁況は良好である事が認められた。

Ⅶ 文　　献

UDA, M. (1925). On the relation betwecn the variation in the impprtant fisheries conditions and oceanographical conditions in the adjacent waters of Japan. Jour. Tokyo Univ. Fish. **38** (3).

川　名　　武 (1935). 鮪は日本海において産卵す。水産研究誌 **30** (6).

諫　早　隆　夫 (1936). 北海道日本海沿岸の鮪について。北水試旬報 277号

宮　本　秀　明 (1947). 定置網漁論　東京，河出書房

山陰東部沿岸におけるスルメイカ漁況と海況について

永　田　俊　一

On the Relation between the Fishing Conditions of Cuttle Fish (*Ommastrphes sloani pacificus*) and the Oceanographical Conditions in the Coastal Region of the Eastern San-in District.

by

Shunichi NAGATA

Abstract

The coastal region of the eastern San-in district is a favorable fishing ground of cuttle fish (*Ommastrphes sloani pacificus*) in summer season in the Japan Sea. The fishing season is June through September. The average annual landing in 1952 through 1954 exceeded 1.80 million Kan, but this value declined to about 700 thousand Kan in 1955 and 1956, thus an abrupt change has been seen in the landing in these five years. Furthermore the fishing ground which was formed about ten to twenty miles off in 1952 and 1953, has moved off year by year since 1954.

Oceanographical conditions also changed during 1952 through 1956. In 1952 through 1954, an outstanding cold water mass stretched coastward developing upwellings, while, in 1955 and1956, such cold water mass could not be found, and the warm current water attained to 200 meters in depth in off shore region.

From these situations,-the fishing conditions of cuttle fish in summer season in the eastern San-in district is good when the cold water mass develop during the fishing season, while it is unfavorable when the warm current water reaches the depth of 200 meters in 40 miles off, and cold water mass undevelop.

I　緒　　言

鳥取県より経ケ岬にいたる山陰東部沿岸は日本海でも有数な夏イカの好漁場として知られており，その一本釣漁業は当地方の夏期における最も重要な沿岸漁業である。

成沢，家久（'36）は但馬のスルメイカ漁況について雨天は悪影響をおよぼし，表面水温は低いほど漁況は良好であると述べ，花沢（'50）は7月の表面水温が24.5°C の時漁況は最も良好でそれより高温，あるいは低温になるにしたがつて漁獲は減少してゆく傾向がみられると報告している。又豊岡測候所では但馬沿岸のスルメイカ漁獲高と冬期における気温，日射との間には正相関，降水量との間には逆相関がみられ5月に本土，隠岐の島間の水温が高温でかつ6月，7月に南風が多く吹いた年は好漁であると発表している。

筆者は対馬暖流調査のいつかんとして昭和27年より31年までの山陰東部沿岸のスルメイカ漁況について海況上より考察を加えたところ，両者の間に密接な関係がみられたのでここに報告する。なお本調査に協力していただいた渡辺技官，樋口喜代子，仲山秀子にあつく感謝する。

II　漁　　況

山陰東部沿岸の夏イカ1本釣漁業は6月から10月上旬頃までを漁期とし，盛漁期は7月より9月上旬までで

ある。漁場は第1図に示すごとく，鳥取県の天神川より経ヶ岬沖合にわたる距岸40浬以内の海域に形成され，特に兵庫県沿岸は好漁場をなしている。

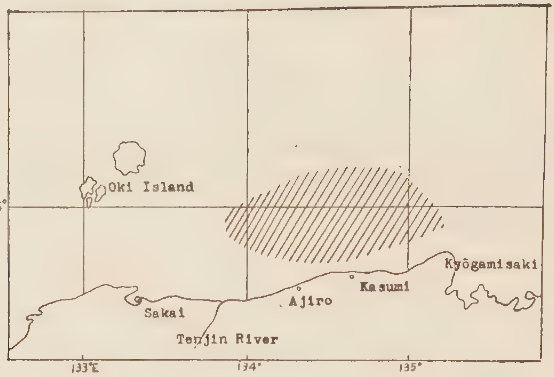


Fig. 1　Location of the fishing ground.

いま昭和27年より31年までの同海域における夏イカの年別漁獲高と，それが日本海全体（山口～青森）の夏イカ漁獲高に対して占める割合をもとめると第1表のごとくである。すなわち山陰東部沿岸の夏イカは昭和27年より29年までは毎年 180万貫以上漁獲され，特に昭和28年は日本海全般にわたつて夏イカは好漁であつたが

Table 1　Catch of cuttle-fish caught during summer in the eatern San-in district, and its portion to total catch in the Japan Sea side of Honshu. (unit; Kan)

Year	(A) Total catch in the Japan Sea side of Honshu.	(B) Catch in the eastern San-in district.	(B)/(A)
1952	4,147,000	1,888,000	45.5%
1953	5,413,000	2,269,000	41.9%
1954	5,534,000	1,825,000	32.9%
1955	2,650,000	660,000	24.9%
1956	2,726,000	726,000	26.8%

当海域も 200万貫をこす豊漁にめぐまれた。そして日本海夏イカ総漁獲高（山口～青森）に対する比率も昭和27年，28年は40%以上，昭和29年は30%以上であつた。その後漁獲は急減し30年は56万貫，31年は72万貫と前3年の約⅓程度になり比率も25%前後になつた。すなわち過去5ヶ年間の漁獲高は昭和29年を境として好漁から不漁に一変した。このような漁況の変動をさらに詳細に検討するために同海域にのぞんでいる鳥取，兵庫，京都の過去5ヶ年間の年別漁獲高を第2図，各年の月別漁獲高を第3図に示し，これを各府県別にみると下記のごとくである。

京　都

3府県のうちで最も漁獲高はすくない。昭和27年より29年までは10万貫以上の水揚げがみられ好漁であつたが，30年には約半分の6万貫に減少し，31年も前年よりやや良好な程度でこの両年は不漁であつた。すなわち昭和27年から29年までの3カ年は好漁であつたが，30年以降はかんばしくない漁況であつた。これをさらに月別にみると昭和27年より29年の漁獲曲線は6月より7月，8月にかけて上昇しているが30年，31年は逆に下降し特に8月，9月はそれが顕著である。すなわち好漁であつた3年間は6月に漁獲がすくなく，7月以降は多くなつているが不漁の30年，31年の年は6月に漁獲が多く8月，9月には極端に減少している結果があらわれている。

兵　庫

3府県のうちで最も漁獲高は多い。昭和27年より29年までの3年間は毎年6月より9月の間に100万貫以上の

水揚げがみられ好漁であつたが，30年以降は前３年の½にもみたない不漁であつた。これをさらに月別に検討すると昭和27年より29年までの漁獲は6月が最低で7月，８月，９月はこれより非常に良好であるが30年，31年は６月に最も漁獲が多く７月以降は減少の傾向がみられ特に８月，９月の水揚高は非常に少量となつている。すなわち昭和27年より29年までの好漁時代の漁獲は６月はおもわしくなく，７月以降良好となつているが30年，31年の不漁時代は６月の漁獲高が最も多く7月以降は減少し特に８月，9月は急減するという前３年とはまつたく逆な現象がみられる。

鳥　　取

昭和27年，28年は約60万貫，29年は50万貫とこの３カ年は好漁であつたがその後漁獲は急減し30年は約15万貫，31年は20万貫程度になつた。すなわち鳥取においても前記２府県と同じく，昭和27年より29年までは好漁，30年，31年は不漁という状況になつている。これを月別にやや詳細に検討すると昭和27年より29年までは６月の漁獲が最もすくなく，７月以降は月10万貫以上の好漁を示している。しかし30年，31年は６月の漁獲は前３年に比べ良好であつたがその後はふるわず特に30年の９月，31年の８月は非常な不漁であつた。すなわち鳥取県沿岸も兵庫県と大体同じような漁獲状況をしめしている。

以上３府県の５カ年間の漁況について考察したが各府県とも昭和27年より29年までは好漁，30年，31年は不漁という共通の現象がみられ，かつ好漁の３カ年間は６月以後漁獲は上昇しているが，不漁の２カ年は減少しているという状況も認められる。これを綜合して山陰東部沿岸の年別，月別漁獲高として第４図に示すと昭和27年より29年までの漁獲曲線と30年，31年の漁獲曲線とでは７月以降前者は上昇，後者は下降と明瞭に相反している。

一方漁場についてみると昭和27年，28年は距岸20浬以内に形成されたがその後はだんだん遠くなり，29年は25浬から30浬附近，30年，31年はそれ以遠になつた。そして漁船も28年以後は大きくなり３屯以上の船が大部分となつて隻数も増加しているが，漁獲は逆に減少している状況である。



Fig. 2　Yearly change of cuttle-fish by prefecture (1952–1956).

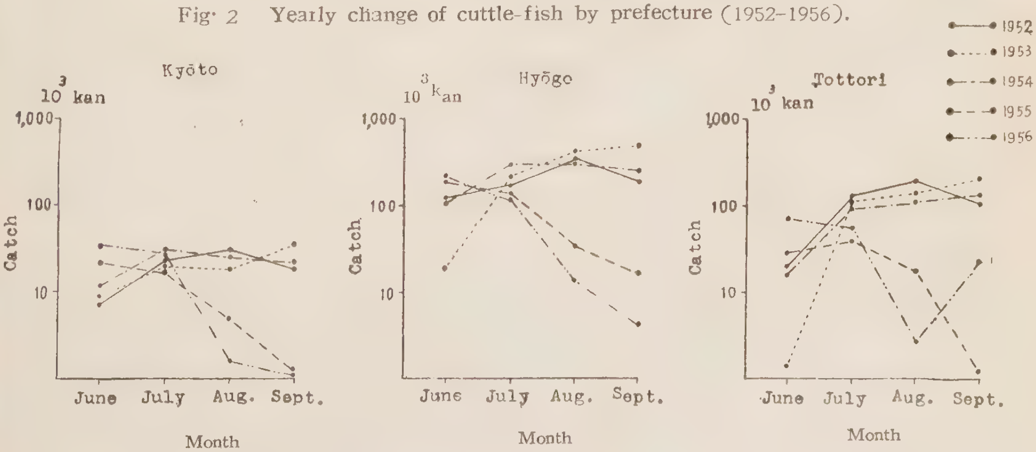


Fig. 3　Monthly change of catch of cuttle-fish by year and prefecture (1952–1956)

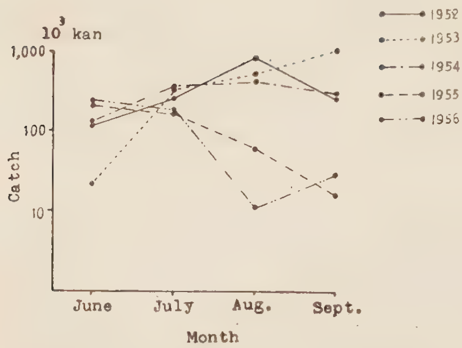


Fig. 4　Monthly change of catch of cuttle-fish in the eastern San-in district by year (1952-1956).

Ⅲ 海　　況

以上のような漁況に対応して昭和27年から31年の夏イカの漁期における山陰東部沿岸の海況状況について考察を加えたが，この場合第3図，4図でもわかるごとくこの5カ年間の当海域の夏イカの好漁，不漁は7月から8月の漁獲がその分岐点となつているので，まず7月の海況について観察した。すなわち舞鶴海洋気象台では毎年7月中旬より下旬にわたつて山陰東部沿岸の海洋観測を実施しているので，その観測点図を第5図，各層の代表として100m層における年別の水温，塩素量，酸素量の水平分布図を第6図より8図，網代沖断面図（*昭和27年は香住沖，昭和28年は経ケ岬NNW沖を加えた。）を第9図に示すと上記5カ年間の7月における当海域の海況の年変化は下記のごとくである。

昭和 27 年

第6図よりみると水温傾度は著しく経ケ岬沖合40浬には水温 7°C，塩素量 18.90‰を示す強勢な冷水域が存在し，それが兵庫から鳥取沿岸に舌状にのびている状況が明瞭に認められる。また溶在酸素量も 5.5～6.0 cc./L とかなり高い値を示し，この海域の冷水の影響の強い事を物語つている。一方断面図より水温 10°C，塩素量 19.00‰線を暖流中層水の下限とすると網代沖では水深 120m 前後，香住沖では距岸60浬以内は 90m～150m の範囲にみられる。そして網代沖では距岸14浬附近，香住沖では距岸 35浬附近に旺盛な湧昇流の存在が認められ，特に香住沖ではこのため塩素量 19.00‰以上の水塊が２分されている。すなわちこの年の7月から８月にかけての山陰東部沿岸海域は経ケ岬沖に存在する冷水域の影響を強くうけ，暖流は浅く，かつ著しく接岸し暖流中層水の下限も 100m～120m 附近にみられる。そして網代沖14浬，香住沖35浬附近には旺盛な湧昇流の存在が認められる。

昭和 28 年

前年よりやや西によつているが経ケ岬沖には水温 8°C，塩素量 19.00‰以下の冷水域が存在し，それが香住より経ケ岬沿岸に指向している状況が明瞭に認められる。また溶在酸素量も昨年と大差なく大体 5.5～6.0 cc./L を示し，上記冷水の強勢な事がうかがえる。しかし鳥取県沿岸は前年よりややすくないようで，等温線の指向方向でもわかるが，この海域に対する冷水の影響は昭和27年の場合より弱いようである。一方網代沖断面図をみると暖流中層水の下限は 150m 前後にあつて，前年よりやや深く，海底にそつた湧昇流の存在がわずかにうかがえる。しかし経ケ岬NNW線の断面図では暖流中層水の下限は網代沖より浅くその深度は 150m以浅にみられ35浬附近（前年とほとんど同じ海域）では湧昇流の存在が明瞭に認められる。すなわち以上のような状況からるみと本年夏期の山陰東部沿岸の海況は昨年同様経ケ岬沖合に存在する冷水域の影響を強くうけ，前年と殆んど同じ海域に顕著な湧昇流の存在が認められる。しかし鳥取県沿岸では網代沖断面図，溶在酸素量よりみて昨年より冷水の影響は弱いようである。

昭和 29 年

網代沖20浬には水温 13.4°C，塩分 19.10‰ 程度の低温域がみられるが，水温傾度は著しくなく全般的に海況は単調である。溶在酸素量は前年まであつた 6.0 cc./L の値が今年はみあたらず，全般的に昨年よりやや少ないが，しかし距岸20浬附近には 5.4 cc./L, 30 浬では 5.6～5.8 cc./L を示す富酸素水塊が沖合広範囲にわたつて存在している事は沖合冷水の勢力が今年も相当強勢である事を物語つている。一方網代沖の断面図より考察すると暖流中層水の下限は 120m 前後にあつて，前年より浅く距岸20浬附近では湧昇流の存在が認められる。

* 香住沖は昭和27年，経ケ岬NNW沖は昭和28年に１回だけ観測を実施しているのみ。

以上のような状況を考察すると，本年の海況は前2年とやや異り冷水域は網代沖合20浬附近に存在し，水温，塩素量よりみるとその規模は小さいようであるが溶在酸素量とその分布状態，暖流中層水下限の水深状況等から考えるとその勢力は昨年，一昨年より弱いとはいえかなり強勢である事が認らられる。

昭和30年

経ケ岬沖30浬には水温 11°C.，塩素量 19.10‰ 以下の低温，低鹹部があり，網代沖80浬附近には冷水域がみられるがその勢力はあまり強くない模様で，暖流は沿岸より沖合に拡がつてゆく傾向が認められる。溶在酸素量は沿岸の一部の海域では 5.5 cc./L を示しているが大半は 5.0 cc./L 前後で29年よりも一段とすくなくかつ沖合より沿岸の方が多いというような過去3年と反対の現象を呈し暖流勢力の強勢な事を物語つている。一方網代沖の断面図よりみると，暖流中層水の下限は 150m～170m の間に認められ，昭和27年以来最も深層に達している。以上のような状況から今夏の山陰東部沿岸の海況を考察すると冷水域は経ケ岬，網代沖にみられるがその規模は小さく勢力も弱いものと推定される。一方暖流は沖合に拡がつてゆく傾向がみられ，網代沖断面図では暖流中層水の下限は 150m 以深にあつていままでになく深層に達している。しかも溶在酸素量は 5.0 cc./L 程度で過去3年間にはみられなかつた低い値を示しており，これらを綜合すると暖流勢力はかなり強勢である事が認められる。

昭和31年

隠岐東方海域には水温 14.0°C.，塩分 19.10‰ 以下の冷水域がみられ南に張り出しているが水温は前年より 2～3°C.，高目である。溶在酸素量は距岸40浬以内では 5.0 cc./L 以下を示しきわめて少なく，網代沖断面図では暖流中層水の下限は 170m～180m 附近にみられ，その深度は前年よりもさらに深くなつている。このような状況から考察すると隠岐の島東方海域にみられる冷水域は一応沿岸にむかつて舌状に張り出しているが水温分布，溶在酸素量，暖流中層水の状況からみるとその勢力は弱いものとおもわれる。一方暖流勢力は昭和30年の時よりもさらに優勢の模様で，したがつて溶在酸素量は昨年よりもさらに少なく，暖流中層水も過去5カ年を通じて最も深層に達している。

以上山陰東部沿岸の昭和27年より31年にいたる毎年7月の海況すなわち水温，塩素量分布，冷水の湧昇状態，溶在酸素量，暖流中層水の到達層等について考察してきたが，これらを綜合して考えると昭和27年，28年，29年の3カ年は冷水が発達しその影響が沿岸部にまでおよんだ年，昭和30年，31年は冷水が沖合にあつてその勢力も弱く，反対に暖流勢力が旺盛であつた年とみなすことができる。

つぎにいままで考察してきた海況は前述したごとく7月を主体としているので当海域における夏イカの漁期全般をながめるにはやや不充分のきらいがある。したがつてそれを補足する意味において鳥取，兵庫両水試が対馬暖流調査のいつかんとして，昭和28年より実施してきた海洋観測結果のうち網代沖と柴山沖の各年の6月より8月までの月1回の観測点図を第10図，年別月別断面図を第11図より14図に示し当海域の暖流中層水の下限ならびに湧昇流の状況を考察すると下記のごとくである。この場合暖流中層水の下限は水温 10°C と塩素量 19.00‰線を照合して決定した。

昭和 28 年

網代沖は観測がすくなく塩素量の値もきわめてたかいので，兵庫水試による柴山沖断面図のみから考察をくわえた。すなわち11図よりみると暖流中層水の下限は，8月ごく沿岸部において 170m附近まで達しているがそのほかは 160m以浅にあつて4カ年のうちでもつとも浅い所にみられる。しかも距岸35浬附近には顕著な湧昇流があり，19.00‰以上の水塊がそのために2分されている状況が明瞭に認められる。すなわち柴山沖の断面図よりみるとこの年の7月，8月における山陰東部海域は暖流中層水は浅く，反面冷水はいちぢるしく発達した事が認められる。

昭和 29 年

第12図よりみると暖流中層水の下限は6月には大体 150m～200m の間にあつてかなり深層に達していたが，7月になるとその深度は浅くなり特に8月の網代沖では 100m～150m の間にあつて，この月だけでは前年よ

りむしろ浅層にみられる状況になつた。一方湧昇流は 7 月に入るとともに柴山，網代沖ともに一段と強勢になり，ために柴山沖では 19.00‰以上，網代沖では 19.20‰以上の水塊が 2 分されている。すなわち本年も暖流中層水は 6 月にはかなり深層に達していたが 7 月， 8 月には浅くなり反対に冷水は 7 月以降強勢になつた事が明瞭に認められる。

昭和 30 年

第13図より暖流中層水の下限を考察すると， 6 月には兵庫の沿岸部において 200m 層に達するものもみられるが，大部分は 170m 以浅に観察出来 7 月にはそれが 170m以深になり， 8 月にはほとんど 200mあるいはそれより深層にみられる状況となつている。一方湧昇流は 6 月には柴山沖35浬附近，網代沖 40浬にはかなり明瞭なものが認められるが， 7 月は網代沖では認められず柴山沖も 200m 附近の深層にみられるだけになり 8 月にいたると柴山沖のものはさらに衰退した形になつた。すなわち30年は前 2 年と異り暖流中層水の下限は 6 月より 7 月，さらに 8 月と漸次深層に達し湧昇流は反対に衰退してゆく傾向が認められる。

昭和 31 年

第14図よりみると暖流中層水の下限は 6 月は湧昇流の関係で柴山沖は 140m～220m，網代沖では 120m～200m の間に観察され，深度にかなりのはばがみられる。 7 月にはやや浅くなつて 170m 前後となり*8月は柴山沖は 160m～220m の範囲にみられるが，網代沖は200m附近にあつて深層に達している。一方湧昇流は6月に網代，柴山沖合ともに旺盛なものが認められるが 7 月には両者ともややおとろえた形態をなし， さらに 8 月には柴山沖の 200m 以深にみられるにすぎなくなつた。すなわち31年の海況も30年とほぼ同様な経過をたどり，暖流中層水は7月より 8 月にかけて深くなり， 湧昇流は6月にもつとも旺盛でその後漸次衰退している傾向が認められる。以上昭和28年より31年までの 4 カ年の網代，柴山沖合の暖流中層水と湧昇流の状況について年毎に考察してきたのがこれを取纒めてみると昭和28年，29年は 7 月， 8 月の盛漁期に暖流中層水は浅く，反面冷水が発達し湧昇流の旺盛であつた年という事がいいうる。 それにたいし昭和30年，31年は 6 月には湧昇流も旺盛であつたが 7 月， 8 月には暖流中層水は深くなり冷水が衰退し湧昇流も消失してゆく 傾向をたどつた年とみなす事ができる。

以上舞鶴海洋気象台の実施した昭和27年より31年までの 7 月を主体にした海況， 鳥取，兵庫両水試の昭和28年より31年までの 6 月， 7 月， 8 月の海洋観測よりみた暖流中層水と湧昇流の状況などをあわせて山陰東部沿岸の夏イカの漁期における海況を総合して考察すると， 昭和27年より29年までは冷水が発達しその影響が沿岸近くまでおよび顕著な湧昇流が認められ暖流中層水は浅かつた年， 昭和30年，31年は 6 月には湧昇流も判然としていたが 7 月以降はそれが不明瞭になり冷水の勢力は弱く， 暖流中層水は距岸40浬附近までは 200mあるいはそれ以深の深層に達した年という事がいいうる。 これを前述の漁況と照合して考察すると，好漁であつた昭和27年より29年までは盛漁期に冷水が発達しその影響が沿岸近くまでおよんだ年， 不漁であつた昭和30年，31年は 6 月にはけんちよな湧昇流が認められたが 7 月以降は暖流中層水は深層に達し冷水は沖合に衰退して湧昇流も明瞭にはみられなくなつた年という事がいいうる。すなわち山陰東部沿岸における夏イカは漁期中に冷水が発達した年は好漁， 反対に暖流が深層に達し冷水が沖合に衰退した場合は不漁という事が明確に認められ両者の間には密接な関係があるようにおもわれる。

Ⅳ 摘　　　要

山陰東部沿岸の昭和27年より31年までの 5 カ年間の夏期におけるスルメイカ漁況と 海況との関係について考察した。

(1) 山陰東部沿岸の夏イカは6月より10月上旬頃までを漁期とし， 盛漁期は7月より 9 月上旬までである。漁場は天神川より経ケ岬にいたる距岸40浬以内の海域に形成される。

(2) 昭和27年より29年までの好漁であつた年は盛漁期に冷水が発達し， 顕著な湧昇流の存在が認められた。

(3) 昭和30年，31年の不漁であつた年は 6 月には湧昇流も 明瞭に認められたが 7 月以降は消失の形をとり暖流

* 柴山沖の 8 月の塩素量は検定されていない。

中層水は深層に達した。

(4) 山陰東部沿岸のスルメイカ漁況は対馬暖流中層水ならびにその下に存在する中間水の消長に密接な関係のある事が認められた。

V 文　献

川 名　武 (1934) イカ，マグロ漁況海況調査総括，北水試旬報 No. 230

成沢不二男，家久 了 (1938) 但馬のスルメイカ漁況について，日本水産学会誌 7 (3)

花 沢 正 策 (1950) 但馬地方のスルメイカ漁況と海況について，大阪管区気象研究会誌 No. 2

豊 岡 測 候 所 (1950) 日本海漁業と気象との関係について，産業気象調査報告 14 (1)

竹 花　毅 (1954) 津軽海峡東口における海況と同海域におけるスルメイカ漁況との関係についての一知見，対馬暖流開発調査 (第1回シンポジウム発表論文)

児 島 俊 平 (1955) 隠岐の島周辺におけるスルメイカの漁況学的研究，日本水産学会誌 21 (4)

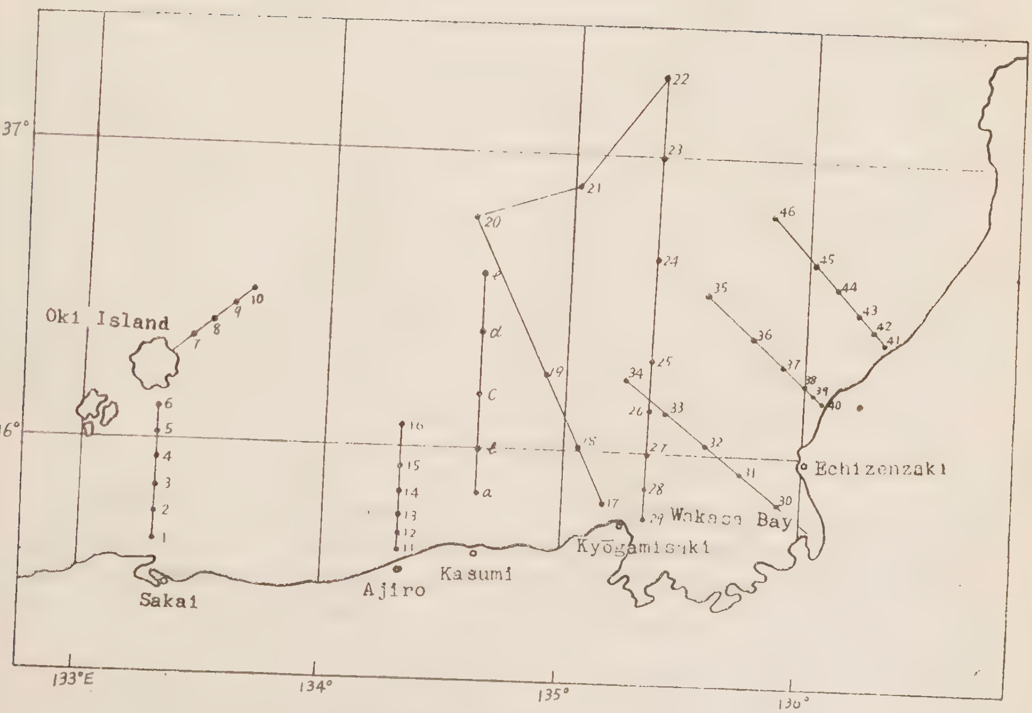


Fig. 5 Position of thestations.

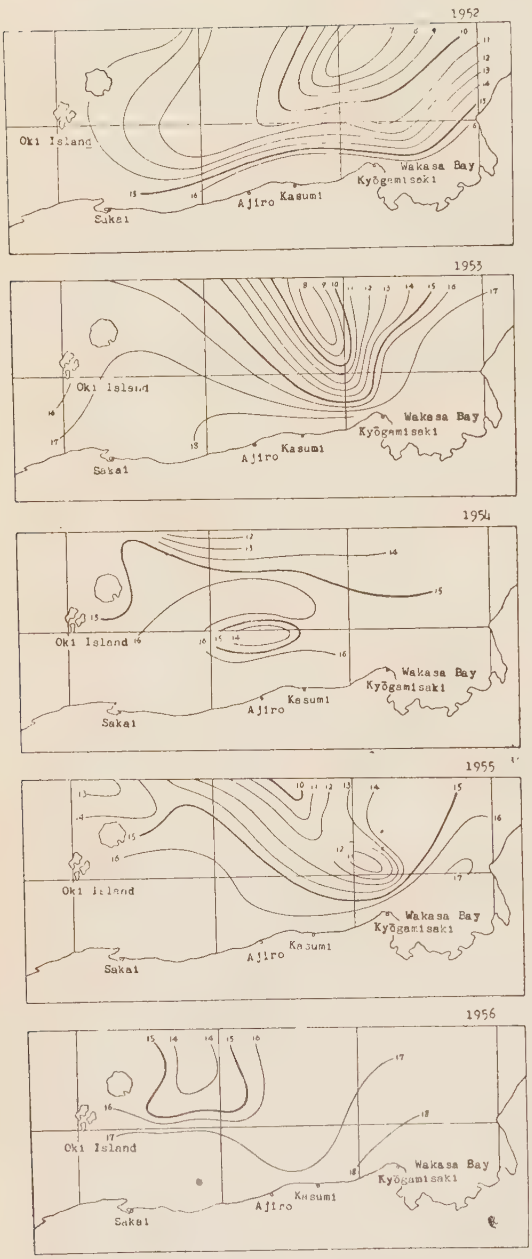


Fig. 6 Yearly variations of horizontal distributions of temperature (°C.) off the eastern San-in district in July during the period 1952 to 1956.

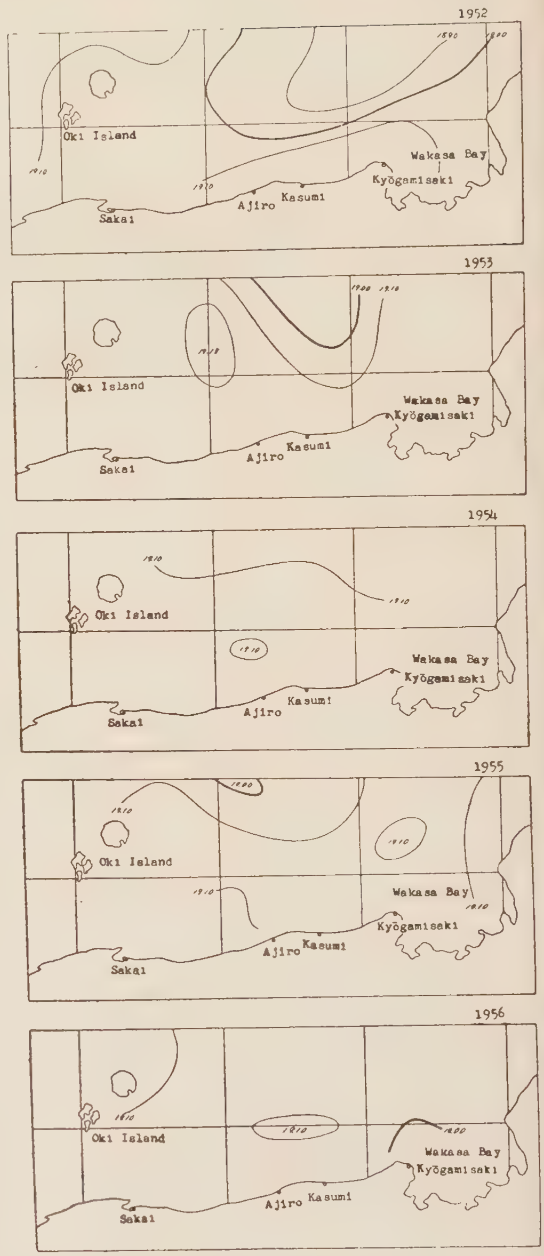


Fig. 7 Yearly variations of horizontal distributons of chlorinity (‰) off the eastern San-in district in July during the period 1952 to 1956.

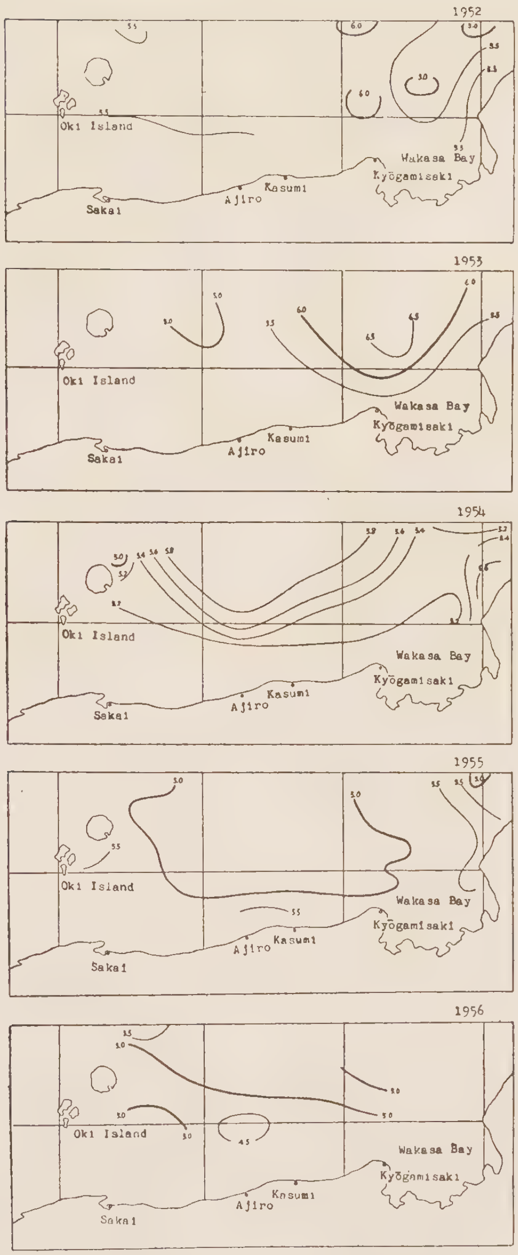


Fig. 8 Yearly variations of horizontal distributions of oxygen content (cc./L) off the eastern San-in district in July during the period 1952 to 1956.

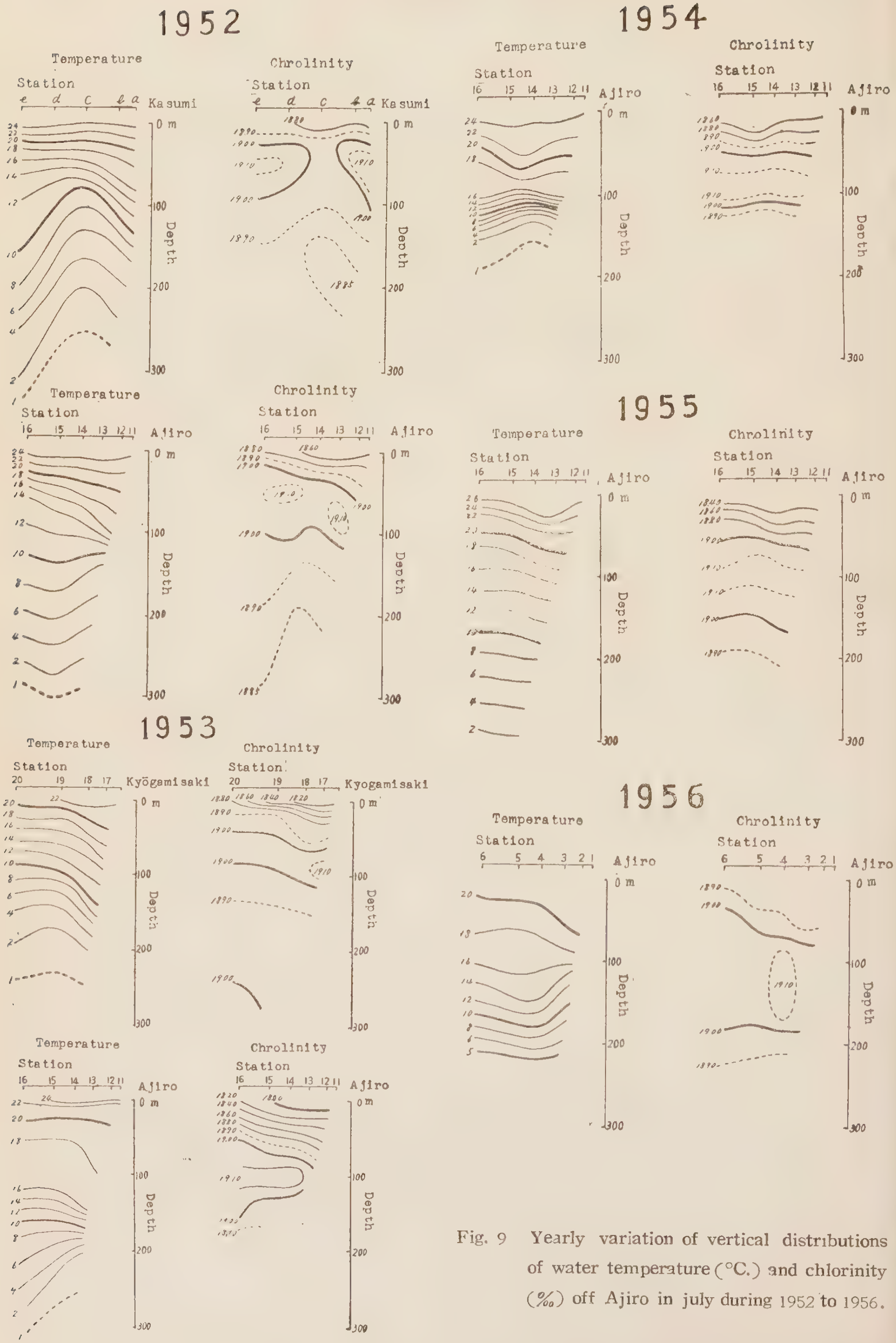


Fig. 9　Yearly variation of vertical distributions of water temperature (°C.) and chlorinity (‰) off Ajiro in july during 1952 to 1956.

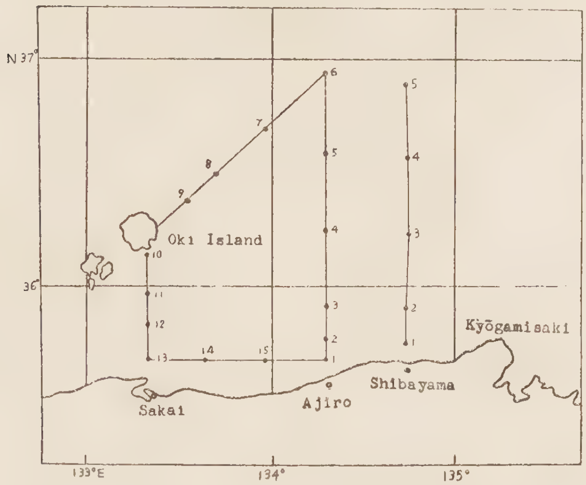


Fig. 10 Position of the stations.

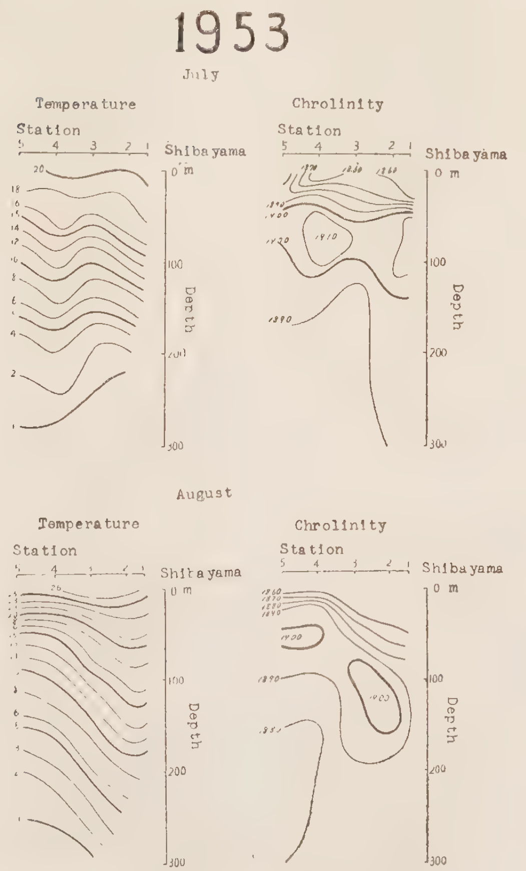


Fig. 11 Monthly variation of vertical distributions of water temperature (°C.) and chlorinity (‰) off Shibayama in July and August, 1953.

1954

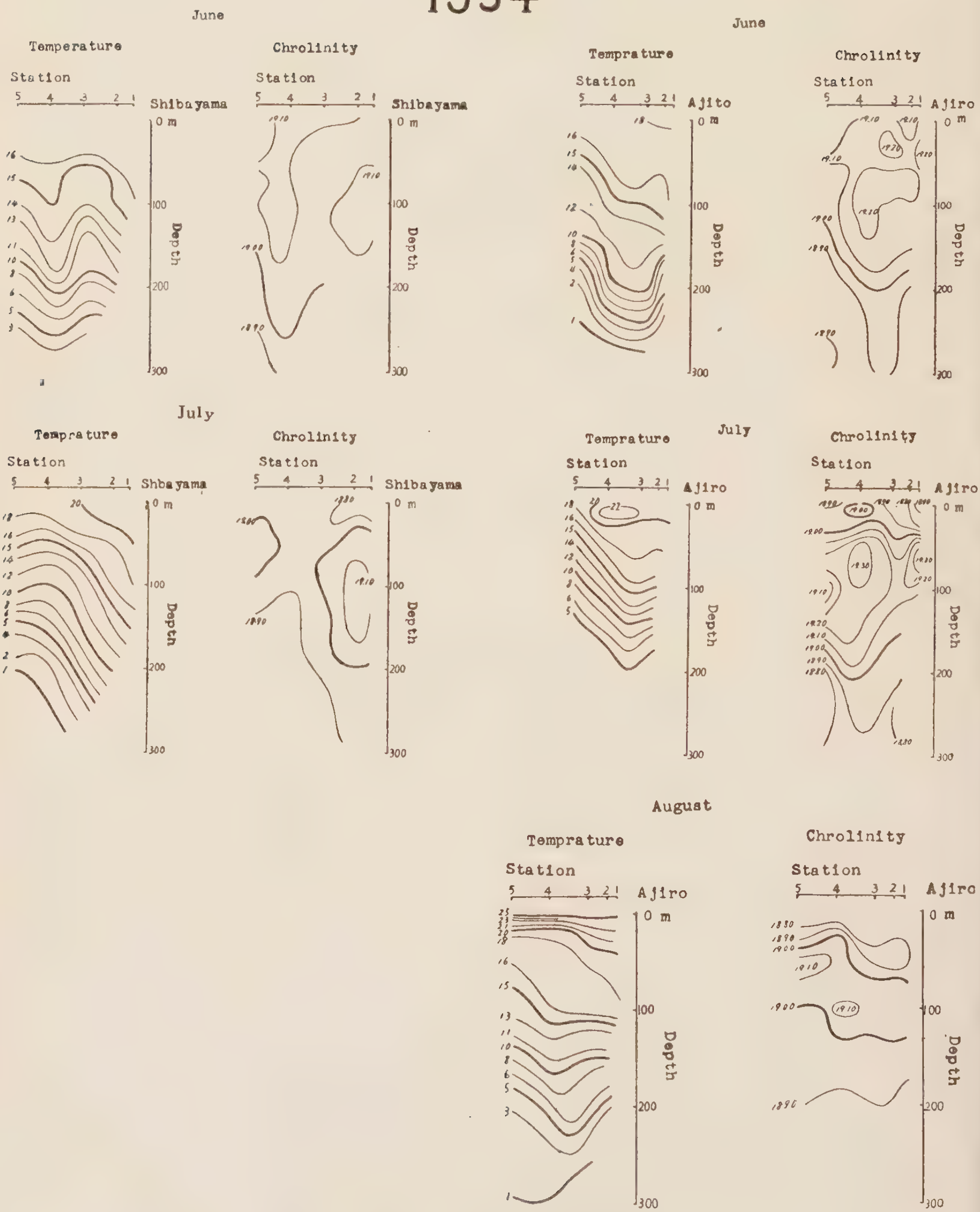


Fig. 12 Monthly variation of vertical distribuins of water temperature (°C.) and chlorinity (‰) off Shibayama and Ajiro in June, July and August, 1954.

1955

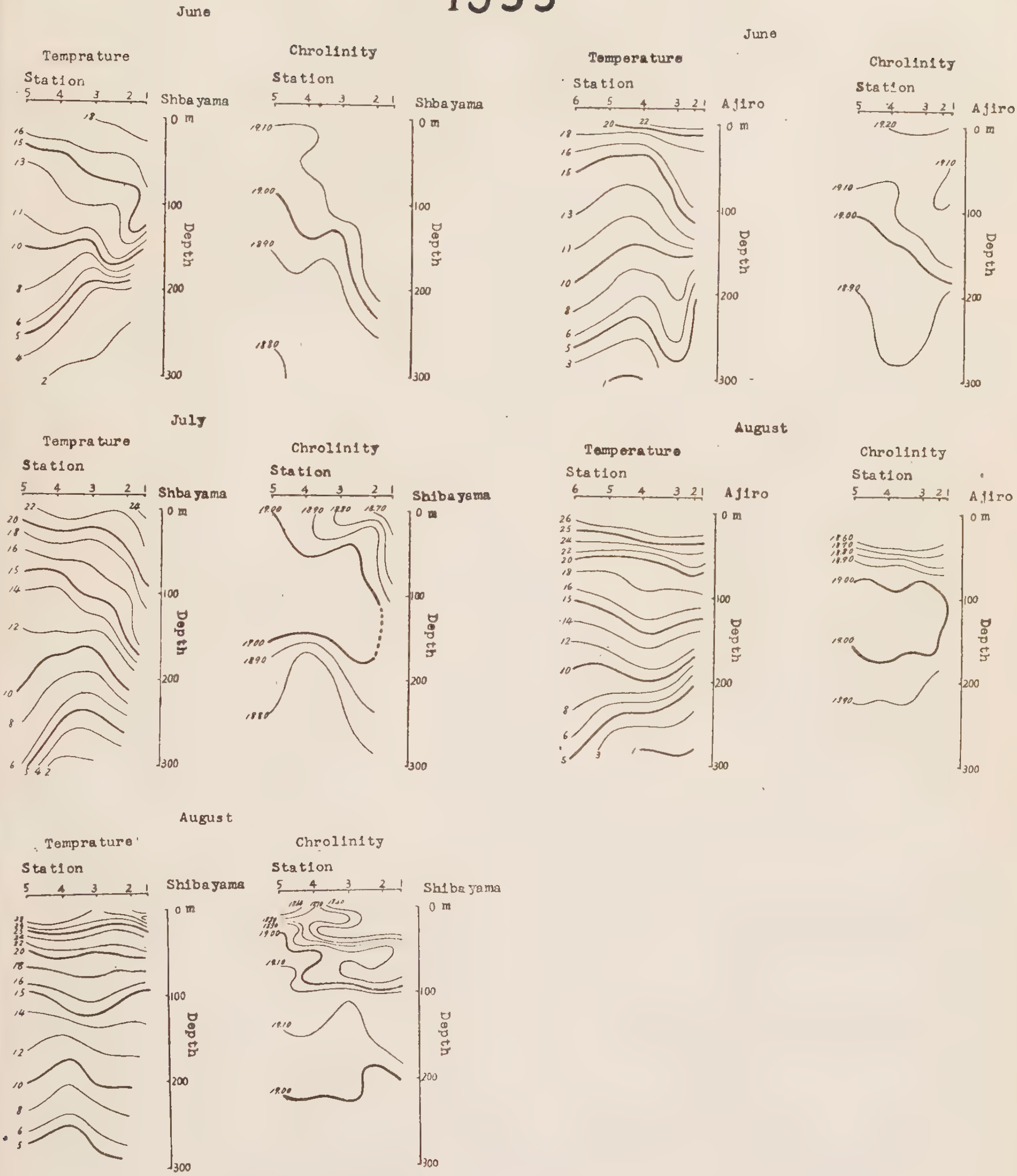


Fig. 13 Monthly variation of vertical distributions of water temperature (°C.) and chlorinity (‰) off Shibayama and Ajiro in June, July and August, 1955.

1956

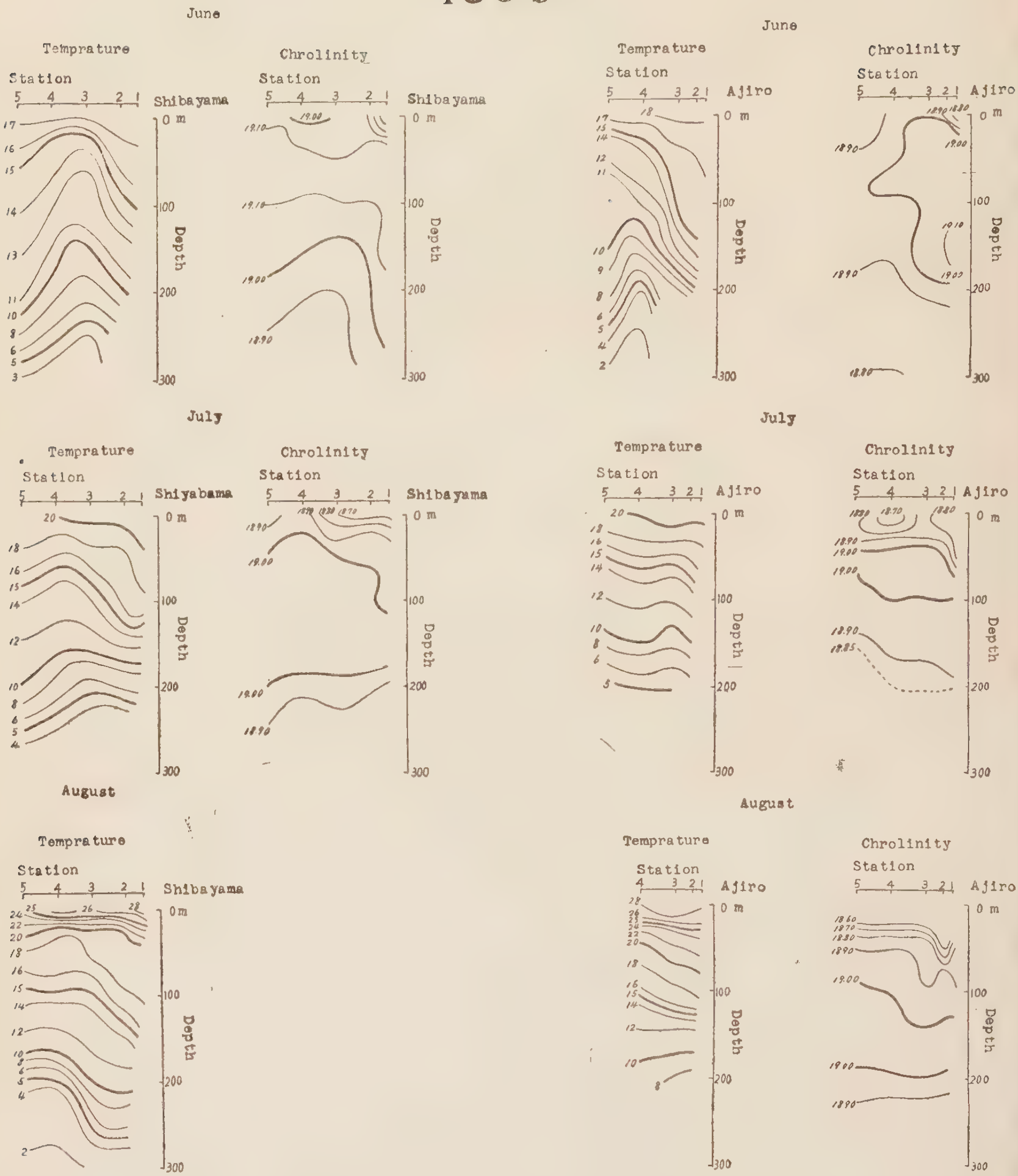


Fig. 14 Monthly variation of vertical distributions of water temperature (°C.) and chlorinity (‰) off Shibayama and Ajiro in June, July and August, 1956.

1956年春季北部日本海に於ける微量栄養成分の分布について

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On the Distributions of Minute Nutrients in the North Japan Sea; March～April, 1956.

by
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Abstract

The second investigation of North Japan Sea was carried out by Tenyo-maru in March and April, 1956. We were in charge of the determinations of minute nutrients (Silicate-Si and Phosphate-P), pH and Alkalinity in this investigation.

In present paper we describe the distributions of these factors and attemt an inference on the structure of water-mass system in spring of the North Japan Sea, comparing the summer condition surveyed in August, 1955.

I. 緒　　言

1955年蒼鷹丸により北部日本海の沖合調査が戦後初めて行われ，多くの成果が挙げられたが，1956年3月末より4月上旬にかけて天鷹丸により，略々同一海域の調査が実施された。今次調査は日本海区水産研究所の「イワシ漁況予報」のための基本的調査が主軸であつたが，われわれは昨夏同様栄養塩類の分析を行い，昨夏の栄養塩分布と比較しつつ水系構造の推定を試た。

調査実施に御尽力を頂いた日本海区水産研究所下村部長，天鷹丸乗組の方達，また船上の作業に従事して頂いた本学科学生安生二郎君に厚く感謝の意を表し度い。

II. 方　　法

第1図に採水点を黒点で示した。今回は採水深度が，0•10•25•50•75•100•150•200•300mの9層に亘る300m深までに限られたが，採水点数はSt• 2•4•6•8•10•12•17•18•20•29•30•31•32•33•34•36•38•40の18点に亘つた。且 St. 30及び34に於ては上記の外400•600•800mの3層からも採水せられた。

測定項目及び分析方法は次の通りである。

（1） Silicate-Si ; Diénert-Wandenblucke の方法を改良した Robinson-Thompson の方法

（2） Phosphate-P ; Denigès-Atkins の方法

（3） pH ; 比色法により温度更正，20°C換算を行う。

（4） Alkalinity ; Machida の混合指示薬（metyl-orange と aniline-blue の各0.1%溶液の1:1混液）使用

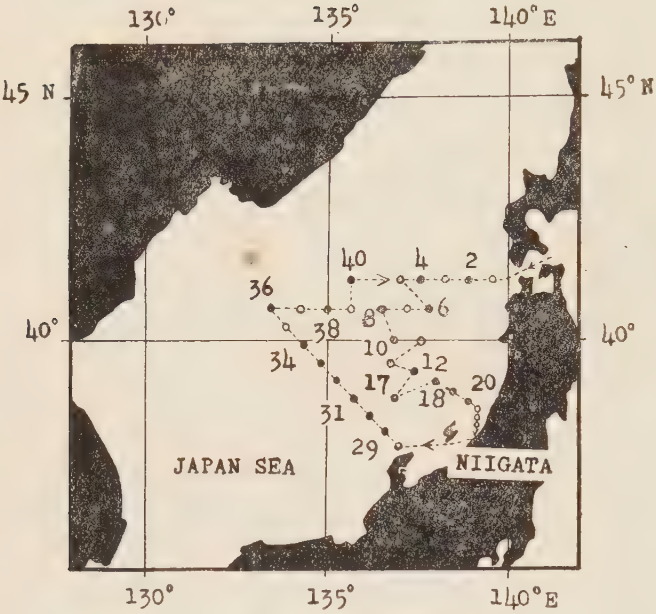


Fig.1 The map showing stations at which water samplings were made (black spot).

Ⅲ. 栄養塩類の分布

上記 Silicate-Si 及び Phosphate-P の分布の一般的傾向を追跡し，また pH, pH 及び Alkalinity から算出し得る Total CO_2 の分布傾向を検討し，調査水域の水系構造の模様を昨夏と対比して論じ度いと思う。

(1) Silicate-Si

対馬本流中に当ると思われる St. 2•18•20•29•30に於ては，表面で150〜200 γ/L,東朝鮮海流域中と覚しき St. 10•32•33ではやや多く200〜250 γ/L 程度である。これらの諸点に於ける垂直分布型を見ると，他点に比し飛躍層が深部に存在し，150m 附近で急増し，400 γ/L から 200m で 800γ/L 以上となるところが多い。300m 以深の採水がなされなかつたので深層の分布に関しては詳細に論ずべくもないが，800m まで採水された St. 30•34の例では300m以深で，1,000〜1,500 γ/L の値が得られている。同様他点でも300m 以深では日本海固有水の停滞を物語るものの如く，以後1,000〜1,500 γ/Lの値に集約してゆく分布型を示す。

上記以外の諸点では表層に分布する Silicate-Si の量も比較的多く400〜550 γ/Lを示す。またこれらの点では，飛躍層深度もずつと浅くなり，50m附近から Silicate-Si の分布量が急増している。特に顕著なのは St. 12•17•34•36•40等であつて，100m深に至れば850〜1,000 γ/L以上の値を示す様になる。

第２図に能登半島輪島沖よりNWに向う線に沿つての Silicate-Si の分布断面図を示したが，概観的に見るなら昨夏８月の同線に沿う分布断面図と近似の傾向にある。しかし東朝鮮海流の存在を暗示する St. 33を中心とした Silicate-Si に乏しい水の北方への張出しは，極めて表層に限られている点，及び St.32•33は丁度大和堆の両側上に占められた観測点であつたが，此処には海底隆起から期待される湧昇流とは逆に，顕著な分布の谷が形成せられている点注目に値いする。

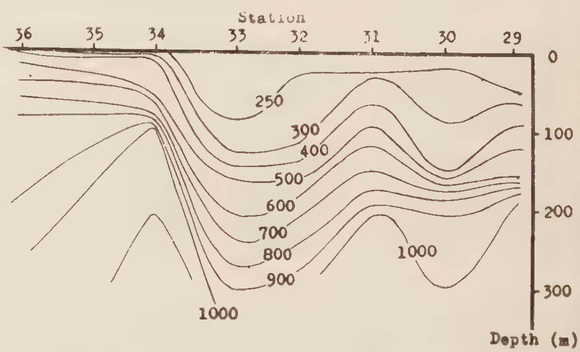


Fig. 2 Sectional distribution of Silicate-Si, along the NW-line from Noto Peninsular (γ/L).

(2) Phosphate-P

対馬本流域に当ると思われる St. 2•18•20•29•30 等では表面で数 γ/L と言つた微量であるが，多くの点では 10 γ/L 以上であり，北方系水の張出した水域にあたる St. 4•6•8等では20 γ/L以上，30 γ/L にも及ぶ。当然のことながら暖流系統の水の卓越すると思われる水域で占められた点に於ける Phospate-P の垂直分布の型では，飛躍層の深度が深く150m附近から Phosphate-P 量が急増する傾向にあり，北方寒冷水の影響下にある諸点——例えば St. 4•6•8•34•36•40等に於ては，飛躍層深度は浅く25〜50m附近から Phosphate-P 量の急増を

見る。

大体の傾向として前者では10m層で30 γ/L前後，200m層で45～50 γ/L，300m層で50～60 γ/LのPhosphate-P 分布を認めるが，後者では50m層で既に30 γ/Lを越える点もあり，100m層で 40 γ/L，200m 層で 50 γ/L前後，300m層では50～60 γ/Lの値が得られている。

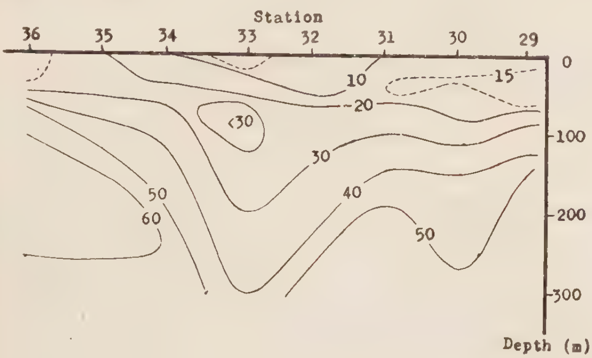


Fig. 3 Sectional distribution of Phosphate-P, along the NW-line from Noto Peninsular (γ/L).

能登半島輪島NW沖に向う線に沿つての分布鉛直断面は第3図に示す通りであり，これ以外の代表的な垂直分布の型を示す点について第9図に示した。断面図からも明らかな様に，対馬本流域の St. 29•30 から St. 31 の方向に向い Phospate-P に乏しい表層水の張出しが認められる。また St. 33 を中心として東朝鮮海流が存在することを裏付けるが如く，Phosphate-P の分布の谷が形成せられている。即ち，Silicate-Si の分布断面ひいては水温・塩分の分布断面と近似の断面を形成している。

（3） pH, Alkalinity 及び Total CO_2

昨夏の栄養塩分布に関する報告中に述べた通り，pH 値の分布比較には 20°C に補正換算した値（pH_{20}）を用いるべきであり，今回もこの通りにし，亦現場水温に於て示すべき pH(pH_{tw})をも同時に求めて見た。

能登半島輪島 NW沖線に沿つての断面図は pH_{20}，pH_{tw} の各々につき，第4図及び第5図に示す通りである。またこの線以外の代表点の pH_{20}の垂直分布につき第10図を描いた。

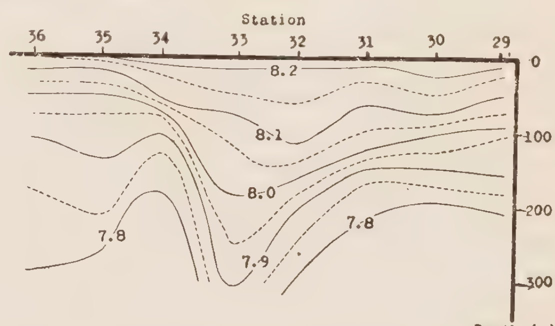


Fig. 4: Sectional distribution of pH (at 20°C), along the NW-line from Noto Peninaular.

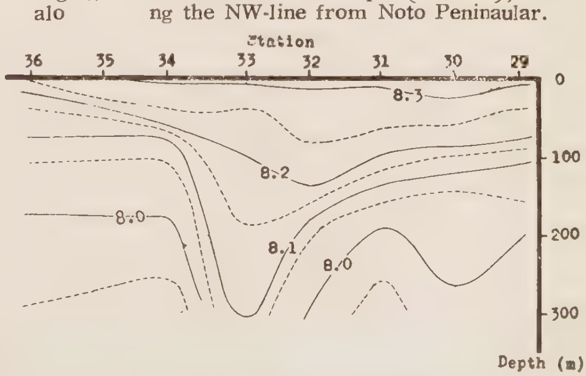


Fig. 5: Sectional distribution of pH in situ, along the NW-line from Noto Peninsular.

表面では低緯度でpH_{20} 8.1～8.3の値が示され，高緯度では pH_{20}8.0～8.1の値が得られた。暖流系水の影響下にある点では，上記栄養塩類の分布と同じく，飛躍層が深部にあり寒冷水の影響が下層に顕著な箇処では浅部に位置する。St.33 では東朝鮮海流の流路を暗示するべく，緩やかな分布傾度が認められ50m層で pH_{20} 8.15，100m 層で 8.05，200m層で 8.0，300m層で7.9 の値が示される。一般的には 200m 以深となると pH_{20} 7.8 以下の値を各点ともに示す様になる。

pH_{tw}の分布断面も pH_{20} のそれと似通つた様を示すが，細部に亘つては，多少の差異があることが第4・5図の対称から認められるであろう。

Carbonate alkalinity は各点とも大差はない。即ち表層で 2.45 meq/L 前後，深層に及ぶと2.50～2.55 meq/Lである。

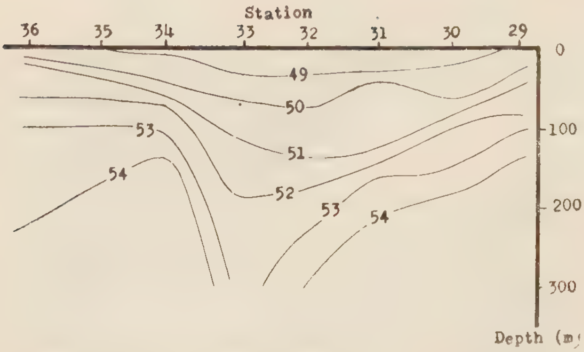


Fig.6 Sectional distribution of total carbon dioxide, along the NW-line from Noto Peninsulr (cc/L).

Total CO_2をpH_{20}とCarbonate alkalinityとから算出し，能登沖線についての分布断面図を第6図に示した。他の要因と同じく，St. 33を中心とした分布の谷が認められる。

Ⅳ．水系構造についての推察

以上の諸要因の分布状況から推して，調査水域に於ける水系構造を昨年夏のそれと対比しつつ推論してみよう。

先ず水温について各点に於ける垂直分布型により，類似の型態を有するものをまとめ上げると第1表の如くなる。このgroup 1〜4の代表的な分布型は第7図に示す通りである。第1表中の能登沖線の各点に於ては，1及び3の中間的分布を示すgroupを形成するのでこれを2′とした。

Table. 1: The station groups divided by the type of vertical distribution of water temperature.

Group	Station No. Before Niigata	Station No. After Niigata
1.	St. 4, 6. 8.	35, 36, 38, 40.
2.	St. 10, 12.	(2′) 29, 30, 31, 34.
3.	St. 2, 17, 18,	(2′) 29, 30, 31, 34.
4.	St. 20.	33.

Notice: The vertical distributions at under lined stations are shown in Fig 7. as the representative types of each group

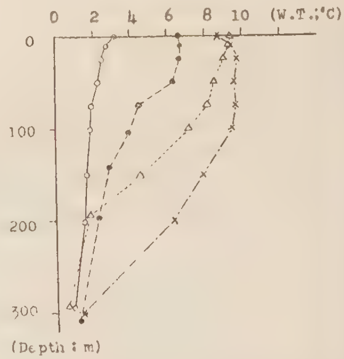


Fig. 7: The representative types of vertical distributions of water temperature, among stations before Niigata.

Silicatf-Si, Phosphate-P 及び pH_{20} の垂直分布型についても，水温のそれと平行的な分布型が認められ，新潟までの観測点につき代表点に於けるそれを第8〜10図に示した。

第11図に，栄養塩類の分布を基礎に他要因をも併せ考えて水系構造の模式的な様相を示した。即ち能登半島沖を北上する対馬本流は，St. 29•30を通過しSt. 7•12をかすめてSt. 2に至るものであろう。St. 18附近からの暖流の一分枝が，山形県沖に向け東流St. 20を流域に含み再び北上津軽沖に至るのであろう。また暖流の一大分枝である東朝鮮海流は，St. 33を流由の中心に大和堆上を北東流する。この結果St. 32•33には栄養塩分布の断面にも分布の谷が形成せられるものと思う。夏季に対比して東朝鮮海流の流路は大分本州寄りに接近していることが判る。其の後St. 10•12附近で対馬本流と合流し北上を続け，St. 2に垂直分布傾度の少い栄養塩の分布を出現せしめるのであろう。

暖流系のこれ等2大分枝により囲まれる水域には東朝鮮海流の下層を潜った北方系寒冷水，或いは深部の日本海固有水が，反時計廻りの渦流に誘発されて湧昇し，栄養塩の垂直分布傾度の大なるSt. 17を出現させ，またその影響がSt. 31附近にまで及んでいるものであろう。対馬本流とSt. 12附近から分れる分枝により囲まれたSt. 18附近の水域でも，表層はこれら暖流系貧栄養の水層に覆われながらも，中層には栄養塩の顕著な躍層が存在し，渦流による底層水の卓越を物語るものと言えよう。

夏季に比べ冬季の北西季節風卓越の予後或いは沿岸洲沿岸で形成せられる寒冷水の張出しを物語るものと思われるが，前線の形成は夏季より南部に於て行われている模様で，それを裏付ける様に，東鮮海流の外縁比側

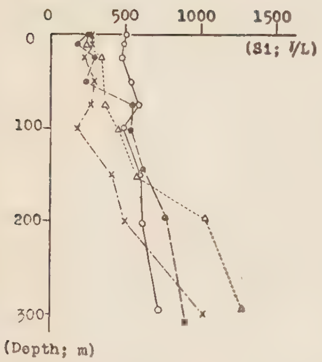


Fig. 8 The representative types of vertical distributions of Silicate-Si, among stations before Niigata.

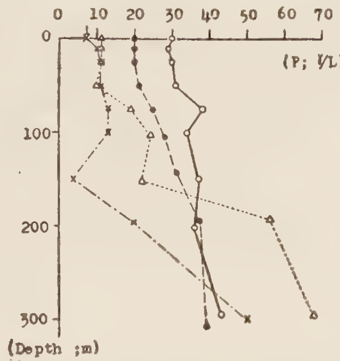


Fig. 9 The representative types of vertical distributions of Phosphate-P, among stations before Niigata.

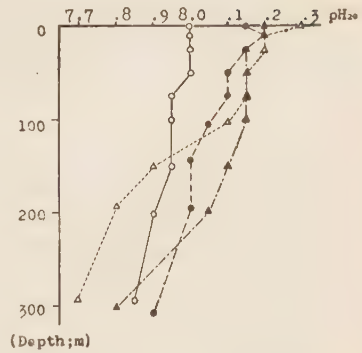


Fig. 10 The representative types of vertical distributions of pH_{20}, among stations before Niigata.

○——○ St. 8, ●---● St. 10, △······△ St. 18, ▲-·-·▲ St. 20.

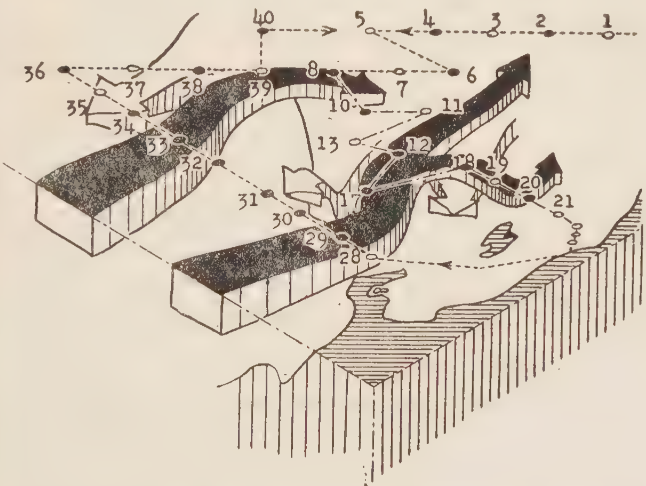


Fig.11 Schematical illustration of water-mass system in the North Japan Sea.

に沿い St. 34•38•40•4•6 といつた諸点で，栄養塩類の量も豊富であり，垂直分布傾度も大となつている。

大和堆をはさんで占められた St.30•34では300m 以深400•600•800m の3層からも採水せられ，両点に於ける Silicate-Si, Phosphate-P の垂直分布を第12図に示した。両点に於ける 200m 以浅層での分布傾度に顕著な差のあることは，表層を覆う暖流系貧栄養の水の卓越状況によるものと解釈出来ようが，300m 以深の栄養塩量に見られる差は何により惹起せられるものであろう。これは昨年夏季の調査でも認められたものである。

水温•塩分の分布からは深層水系の解析は至難であると従来指摘されているが，日本海々底には最上堆•大和堆•春風堆•隠岐堆等々と本州に平行して走る幾つもの海底隆起があることから，これら海底隆起の間にはさまれた海谷状の場所では，或程度独立した物質循環の系が形成せられており，栄養塩の深層に於ける分布に量的な差異として表われるのではあるまいか。尤も日本海固有水の起源或いはその更新の問題等に関して，深層でも以外に豊富な酸素量が認められているし，尚疑点の残るところである。強いて推論を下せば，200m 以浅層の栄養塩の水平•垂直分布は対馬暖流各分枝の消長，北方系水の張出しの程度等に支配せられ，深層では海底形状に伴つて多少の独立性のある分布をなすものではあるまいか。

V. 要　　約

1956年3月下旬より4月上旬に亘り，天鷹丸によつて行われた第2次北部日本海沖合調査に於て，栄養塩(Silicate-Si 及び Phosphate-P), pH. Alkalinity の測定を行い，これらの分布及び pH. と Alkalinity とから算出した Total CO_2 の分布を記述した。

これらの分布から調査水域に於ける水系の構造を推論し，表層の栄養塩分布は主として対馬暖流各分枝の消

長に支配せられ，深層部では海底地形に伴つた或程度独立性のある系の下に分布が支配せられているかも知れぬことを指摘した。

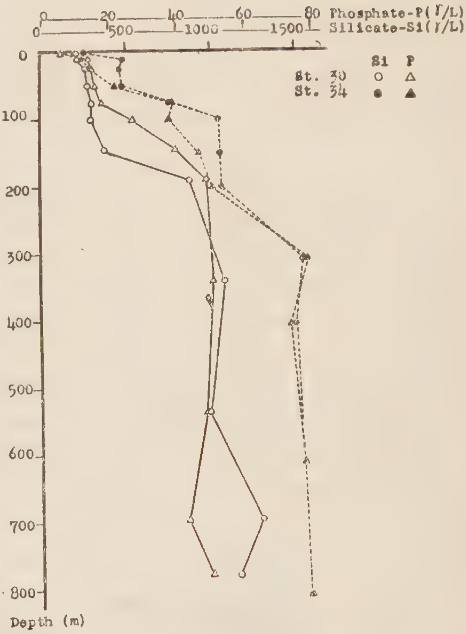


Fig. 12 The vertical distributions of Silicate-Si and Phosphate-P at the stations 30 and 34.

Ⅵ. 参 考 文 献

朝鮮総督府水産試験場 (1933)； 海洋調査要報 No. 8 昭和 8 年海洋観測成績

福岡県水産試験場 (1953)； 東対馬水道海洋観測資料 (大正 2 年 9 月～27年 5 月)

Fleming, J.A. et. al. (1945) : Observations and results in physical oceanography. Sci. Res. Cruise VII of Carnegie, dur. 1928-29 under comm, Cap. J.P. Ault. Oceanogr. 1-B.

Harvey, H. W. (1955) : The chemistry and fertility of sea waters. Cambridge Univ. Press.

神戸海洋気象台 (1934)；第 4 回及第 5 回日本海北部海洋観測調査報告 (昭和 6 年6•7•8•9月， 昭和 7 年7•8•9•10月施行，海洋時報 6 巻 1 号 pp. 1～102.

Matida, Y. (1953) : Some notes on the method of alkalinity determination. Bull. Jap. Soc. Sci. Fish., Vol. 19, No. 5, pp. 703-709.

日本海区水産研究所 (1951)；昭和26年夏対馬海流域一斉観測結果

日本海区水産研究所 (1952)；昭和27年夏対馬海流域一斉観測結果

日本海洋学会 (1955)；海洋観測指針

西 田 敬 三 (1955)；日本海及その隣接海域の海洋調査成績 No. 2

Sverdrup, H.U. et. al. (1942) ; The oceans, their physics, chemistry and general biology, Printice-Hall, Inc.

須田晥次・川崎英男 (1929)：日本海の一横断面について。海洋時報， 1 巻 2 号pp. 134～146

須田晥次・其の他 (1930)；日本海南部海洋観測報告 (第 1 報)，海洋時報 2 巻 1 号 pp. 1～73

須田晥次・其の他 (1930)；日本海南部海洋観測報告 (第 2 報)，海洋時報 2 巻 2 号 pp. 155～264

須 田 晥 次 (1930)：漁況の変調と日本海固有の深層水，海洋時報 2 巻 3 号 pp. 534～535 (雑報)

須田晥次・日高孝次 (1932)：第 2 回日本海南部海洋観測調査報告 (第 1 報)，海洋時報 3 巻 2 号 pp.291～375

須田晥次・其の他 (1932)；第 2 回日本海南部海洋観測調査報告 (第 2 報)，海洋時報 3 巻 3 号 pp. 545～619

須田晥次・其の他 (1932)；第 3 回日本海主要部海洋観測調査報告，海洋時報 4 巻 1 号 pp.1～174

宇 田 道 隆 (1934) 日本海及其の隣接海区の海況 (昭和 7 年 5•6 月連絡施行日本海第一次一斉海洋調査報告)，水産試験場報告No. 5 pp. 57～190

宇 田 道 隆 (1934)：日本海・黄海・オホーツク海の平年各月海況 (連絡試験調査)，水産試験場報告 No. 5 pp. 191～236

昭和28年日本海漁況の経過

（1953年1月～12月）

下　村　敏　正

A General Review of the Japan Sea's Fishing Conditions in the Year 1953

by

Toshimasa SHIMOMRUA

I　は　し　が　き

この報告は，昭和26年以来第1図様式により，下記各地（第2図）から受けている，旬毎の漁況報告の内，

水産庁駐在員：

山形県豊浦・新潟県直江津・能生・富山県魚津・鳥取県境

漁業協同組合：

秋田県八森・新潟県両津・石川県西海・金石・橋立・福井県漁連敦賀支所・同小浜支所・京都府下宇川・鳥取県田後

その他：

大洋漁業株式会社現場（対馬佐須奈・福井県小浜・石川県北大呑・富山県四方・新潟県佐渡ケ島・北海道石狩湾），日水研香住支所（兵庫），同隠岐島支所

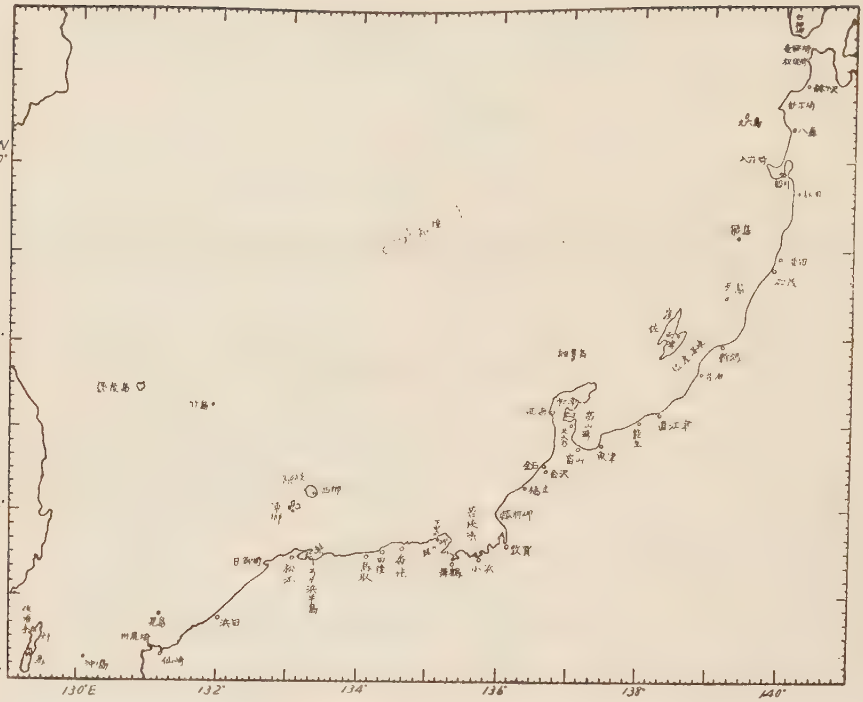
昭和28年1月～12月の分をとりまとめたものである。これら各地からの報告は，26年3月以来逐次整理して，日水研開発部から「日本海漁況概報」（旬報）として，各府県水産試験場，その他水産研究機関，当業者に対し，

調査地　　　　　　漁　況　旬　報　　　　報告者　　月　　旬

項目 ＼ 魚種別					其　の　他
漁具及漁獲量					
漁　　場					
漁獲の前年比					
平均体長及び体重					
漁期の遅速					
海洋気象状況及出漁日数					
例年に比し変つて居る事					
漁況の見通し					
延出漁船数					
参考事項					
其　の　他					総　漁　獲　高

日本海区水産研究所

第1図　漁況報告様式



第2図 日本海主要地名

旬300部を発行して来た。この旬報の目的は，戦後以来無線による速報が不可能であつたため，日本海全体にわたる旬間漁況の速報及び漁況の大要を把握することにあつた。

なお，この報文のとりまとめにあつては，各府県水産試験場の各種報告，農林省統計調査部発行の「農林省統計表」，「農林水産統計月報」その他を参照した。前記各地の報告担当者各位及び各府県水産試験場の各位に対し，深甚の謝意を表します。また図版の清書については，日水研開発部町中茂技官の手を煩わしたことをここに記し，以て謝意にかえます。

最後に，漁況は漁獲対象により，地方により，状況を異にすることが非常に大きく，それらを日本海全体にわたつて，統一的に記載することは不可能に近いので，この報文では概観的に取扱うこととした。データの関係上，記述に精粗の点のあることは止むを得なかつた。一方つとめて，誤なからんことを期したが，御批判を得れば幸いである。

II 漁況の大要

昭和27年に引続き，日本海は高温に経過し，多くの重要魚種について，始漁期が数日以上もおくれたり，或は地域的に極端な不漁に見舞れたりした。これが飛躍して，ソ連による間宮海峡の埋立説が流布され，埋立が原因で北方からの寒冷水がせき止められたためであろうとの噂が拡まつたりした。もち論埋立が実施されたとしても，対馬暖流の海況には，全く影響はないのであるが，とにかく，昭和28年の夏は梅雨期に豪雨があり，大洪水が各地に発生した。秋には又台風に襲われるなどの異常気象が見られ，農作物の被害も甚大で，米の生産高は27年比1,200万石の減収（5,500万石）となつた。このため各地に餌を求める熊が山を降りて町に出没し，富山市内にさえ出没して人畜に被害を与えた。

一方海では，春期京都府・兵庫県方面にクラゲの大繁殖があつて，網目が詰るなど，漁業操業上多大の障害

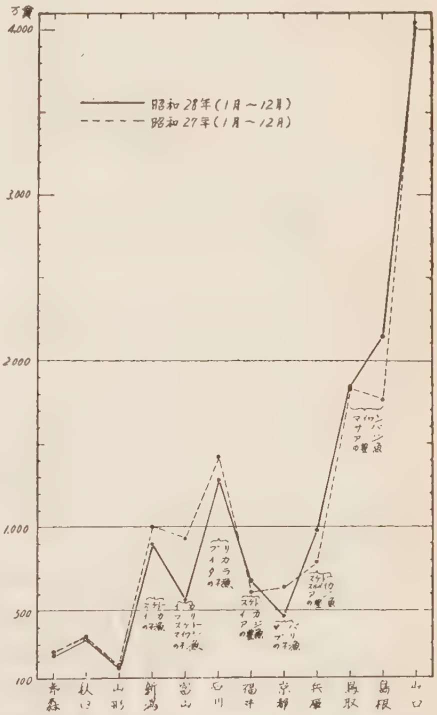
をもたらした。日本海全体にわたつて，かかる現象があつたのかも知れないが，もしそうだとすれば，大旱魃に襲われた昭和25年と軌を一にすることとなる。又隠岐島・能登半島と並んで，日本海におけるサバ巾着網漁業の3大中心地たる，若狭湾方面のサバの著しい不漁，代つて富山湾以西の日本海における中，小アジの大豊漁（例えば島根県は413万〆で，27年の3倍），兵庫県及び石川県以北におけるハタハタの近年にない豊漁（例えば秋田県は67万〆で27年の3倍，10年ぶりの大漁），隠岐島方面における秋イカとブリの大不漁，春期同方面のサバ巾着網の大豊漁のため，鳥取県始まつて以来の最高漁獲高（1,841万〆）をあげた。同県戦前の年間漁獲高は300万〆足らずであつた。

このように，色々興味ある漁況であつたが，28年における日本海総漁獲高は13,595万〆（魚介草類などを含む）で，27年より約600万〆の減少であるが，魚類だけについてみると，約300万〆の増加であり，全国総漁獲高113,686万〆の12%に当る。日本海総漁獲高13,595万〆の25.6%（3,481万〆）は，青森県（権現崎以西）〜石川県の日本海北区の漁獲高である。すなわち福井県〜山口県の日本海西区の漁獲高は，北区の3倍である。かかる大差の生ずる主因は，山口県日本海側の4,009万〆という，北区の総漁獲高を上回る，ぼう大な漁獲高のためである。しかし山口県の4,009万〆の内の80%は，大企業による下関漁港への水揚高であり，山口県漁業に占める下関漁港の重要性，及び沿岸漁業との余りにも大きな差が目立つ。

今各府県別に漁獲高を示すと，第3図となるが，階層別にすれば次のように，一般的にいつて，南方程漁獲高が大である。

500万〆以下　：　青森・秋田・山形・京都
1,000万〆以下　：　新潟・富山・福井
2,000万〆以下　：　石川・兵庫・鳥取
2,000万〆以上　：　島根・山口

これは，漁獲対象物の種類の多いことに比例するが，アジ類・イワシ類・サバ類・底曳網漁獲物の大量なことが原因をなす。



第3図 昭和28年府県別年間総漁獲高

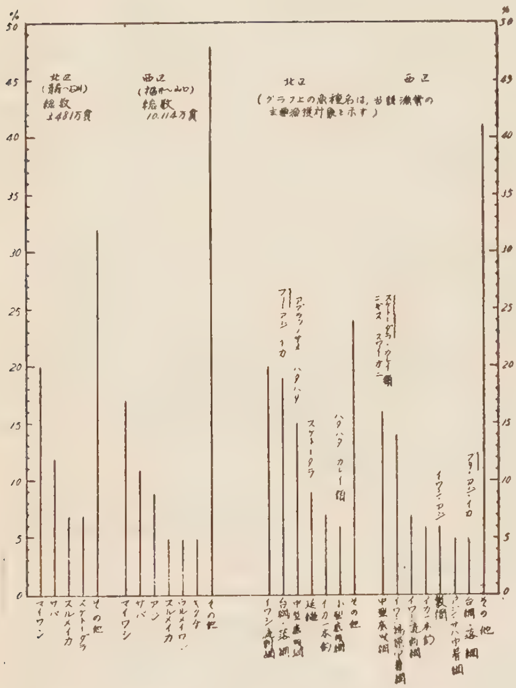
日本海全体を通じてみた場合，総漁獲高13,595万〆の内，500万〆以上の主要漁獲物は，次の7種であり，これだけで日本海総数の60%，7,677万〆を占める。この内，キグチは山口県のみに水揚げされる，日本海としては特殊の魚種である。

魚　　種	日本海総数	日本海総漁獲高に対する比	昭和27年比
マイワシ	2,385 万貫	17.5 %	+ 176 万貫
サバ	1,495 〃	11.0 〃	0 〃
アジ	1,019 〃	7.5 〃	+ 360 〃
カレイ類	870 〃	6.4 〃	
スルメイカ	784 〃	5.8 〃	− 384 〃
ウルメイワシ	596 〃	4.4 〃	+ 164 〃
スケトウダラ	565 〃	4.2 〃	0 〃
キグチ	529 〃	3.4 〃	
計	7,677 〃	60.0 〃	

日本海北区，同西区の主要魚種及び主要漁業は，第4図のとおりである。

27年に比し，漁獲の増加した主なものは，マイワシ・アジ・カレイ類・ズワイガニであり，反対に目立つて減少したのは，スルメイカ・ブリ・スケトーダラ・タラなどである。

日本海全体の漁獲高の月別推移は，全国総数が4月（14,451万貫）と10月（12,516万貫）に山を持つのと，同じ傾向を持つ。今日本海を北区（青森県〜石川県）・西区（福井県〜山口県）に分けて，それぞれの山・谷をみると次のようになる（第5図）。



第4図　昭和28年日本海海区別の主要魚種及び主要漁業

1)　西区の月間漁獲高は常に600万貫以上であるが，北区では3〜5月の300万貫以上を除き，多くは200万貫以下である。

2)　両区共，8月及び1〜2月を年間最低期とするが，最盛期は北区5月，西区4月である。8月は，いわゆる夏枯期で，魚群の洄游なきこと，1〜2月は北西風の卓越期で，月間出漁日数が3〜4日，多くても1週間という荒天のために，最低期となる。

北区最盛期の5月は，次のような魚種の盛期が原因で，5月総数772万貫の60%をしめる。

マイワシ	372万貫	(内，新潟県100万貫)
サバ	92万貫	(内，石川県 80万貫)

西区最盛期の4月は，4月総数1,205万貫の57%をしめる。これは次の魚種の多獲に因る。

マイワシ	187万貫	内，福井県45万貫 鳥取県76万貫 山口県48万貫
サバ	146万貫	(内，鳥取県99万貫)
ウルメイワシ	133万貫	(内，鳥取県99万貫)
スケトーダラ	115万貫	(内，兵庫県80万貫)
カレイ類	105万貫	(主に兵庫県・山口県)

3)　他に北区では12月，西区では10月に，山を作るが，

北区の12月は，12月の総数304万貫の67%をしめる，次の多獲魚種に基く。

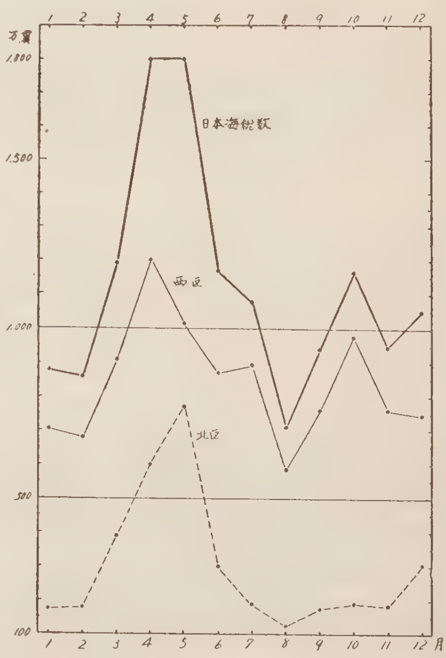
サバ	72万貫	(内，新潟県65万貫)
ハタハタ	62万貫	(内，秋田県51万貫)
ブリ	28万貫	(内，富山県16万貫)
アブラツノザメ	26万貫	(内，青森県25万貫)

西区の10月の山は，次の魚種による。

アジ類	182万貫	(内島根県117万貫)
マイワシ	131万貫	内，鳥取県22万貫 島根県83万貫 山口県19万貫
スルメイカ	86万貫	(若狭湾以西)
サバ	62万貫	(内，鳥取県46万貫)
ウルメイワシ	39万貫	(主に鳥取県・島根県)

その他，兵庫県以西の底曳網による，

キグチ	76万貫	
カレイ類	60万貫	
ニギス	45万貫	
ハモ	23万貫	など。

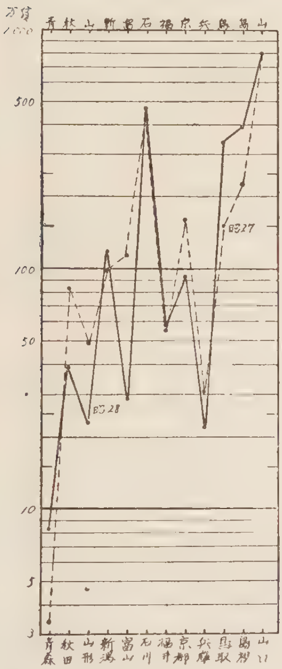


第5図　日本海総漁獲高の月別推移

Ⅲ　主要魚種の漁況

マイワシ *Sardinia melanosticta*

28年の日本海総漁獲高は2,385万貫（全国9,163万貫の26%）で，27年比176万貫の増であるが，これは兵庫県以北の減産にもかかわらず，鳥取県・島根県の豊漁（27年の2～1.5倍）に原因する。全体として，北区29%，西区71%の漁獲であつた（第6図参照）。



第6図 日本海マイワシの府県別・年別の年間漁獲高

日本海の大羽イワシ春漁は，5月下旬ないし6月に，ウルメイワシがとれ出すと終漁となるが，28年の大羽イワシ漁は，昭和27年12月13日を始漁とする山口県の刺網漁業から始まつた。日本海の大羽イワシは，大部分が流刺網でとられるが，山口県の始漁日は，27年比1週間の遅れである。28年の大羽イワシ漁は，鳥取県・能登西岸・秋田県を除いて，全般的に始漁日が27年より遅かつた。これは一つの特徴である。

これら始漁日の早かつた地方についてみると，鳥取県～能登西岸では27年より1旬早く，鳥取県3月19日・石川県3月19日，秋田県八森方面は4日早く5月19日が始漁となつた。しかも豊漁であつたため，鳥取県は例年5月が年間最高漁獲月であるにもかかわらず，28年は4月が最高漁獲月（総数327万貫）となつた。福井県も同じく4月が最高月となつた。

さて全般的に始漁の遅れたことであるが，長崎県平戸島・二神島方面の始漁は1月18日で，例年より1旬遅く，天草方面ではまだ漁が始まつておらず，隠岐島方面は27年より1週間遅く，富山湾・新潟県沿岸も遅かつた。山形県は1旬遅れて，5月中旬に漁期に入つた。特に著しいのは，兵庫県方面であり，香住では，4月上旬隠岐島方面で連日，夜焚巾着網による，大羽，中羽イワシの大豊漁（春イワシ283貫〆，27年の3倍以上）が続いていたにもかかわらず，5月になつても来游なく，7月に入つて漸やく漁らしいものがあつた程度（7月中旬60,000貫，大羽・中羽・小羽の混獲）で，もち論大不漁であつた。

その他の特徴をも列記すれば，

1）全般的に始漁日が1週間以上遅れた。

2）長崎県平戸島・二神島のような南方から，日本海の北部まで，全般的に，

i）ムラ掛りが甚しかつた。すなわち，群は薄くて，漁場範囲が広かつた。

ii）游泳層が深かつた。例えば，山口県川尻埼・見島方面の3月上旬～中旬の樽網の長さは，30尋以上が好漁であり，能登西岸方面における初漁期4月上旬～中旬のそれは，27年15尋，28年20尋以上であつた。

iii）小形魚が多かつた。例えば能登西岸では4月上旬～中旬は，10～30匁の中羽が主であつた。このことは，島根県における，肥満度調査からもうかがわれる（第7図・島根水試）。

夏にとれる小羽イワシ漁も，一般に漁期が遅れ，しかも漁場は沖合に形成された。特に兵庫県方面では，春大羽の大不漁にもかかわらず，夏からは小羽イワシの来游の多いのが目立つたが，イカ・サバと共に小羽漁場は，27年より5浬以上も沖合に形成された。すなわち，7月上旬距岸15浬以遠，9月上旬20浬以遠であつた。

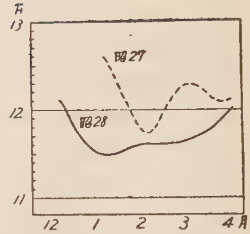
又鳥取県～石川県ではウルメイワシの来游は1旬早く，兵庫県方面の春イワシは，大部分がウルメイワシという，特異現象であつた。漁法別にみると，大羽流刺網漁は青森・新潟・鳥取・島根・山口に良く，石川県～兵庫県の中部日本海では，盛漁期の5月が全く不振であつた。しかし5月，富山湾以北では定置網によるマイワシ（体長10～15cm）は好漁であつた（例えば5月中旬，秋田県八森では1,400貫で，27年の2.6倍）。

7月～11月の間，鳥取県では夜焚巾着網で大羽イワシ，島根県・山口県では夜焚敷網・曳網で中羽・小羽の好漁があつた。

サバ Mackerel

日本海のサバは *Scomber japonicus* を主体とする，新潟以西の魚である。佐渡島・能登半島・若狭湾・隠岐島を四大漁場とする。

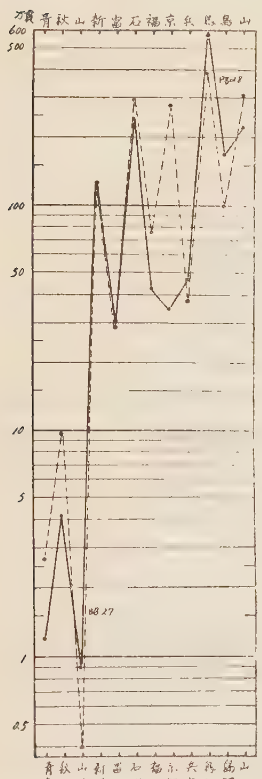
28年の特徴は，若狭湾の大不漁（27年の約⅓，78万貫，最良の年昭和24年の1/10）と，隠岐島方面の大豊漁（27年の1.5倍，500万貫以上）であり，他は大体27年並であつた。若狭湾のサバ大不漁は，若狭湾を始め，西日本海にわたるアジの大豊漁と著しい対照であつた。結局日本海全体としては27年並の1,500万貫（全国6,261万貫の24%）で，内73%は日本海西区の漁獲である。山口県の不漁は，9〜10月の秋サバの不漁（27年の⅕）に基く（第8図参照)。



第7図 島根県大羽イワシ肥満度の年別・月別変化

$$\left(F = \frac{W}{L^3} \times 10^3\right)$$

まず昭和23年以来途絶えていた，美保湾来游の春サバは，7年ぶりに，4月3日から弓ケ浜半島東岸に大挙押し寄せ，4月10日迄に，地曳網によつて120万貫という中サバの大漁があつた。



第8図 日本海サバ類の府県別年別の年間漁獲高

兵庫県方面（例年6月上旬に終る一本釣が，28年は逆に6月から活況を呈した。6月中旬14,000貫）を別として，大羽イワシのばあいとは逆に，全般的に1旬早く始漁となつた(曳釣・延縄・一本釣・定置網・刺網)。特に，佐渡真野湾では，例年より20日も早く，5月中旬に始漁となつた。

4月上旬富山県能生方面では，26年，27年と異り，アジと共にほとんど小形魚のみであつたが，経ケ岬〜兵庫県でも，10月以降は，大部分が100〜150匁程度で，例年比小形であつた。

富山湾は1〜3月の定置網と四つ手網の好漁が幸いして，27年の50%増となつた。

しかし秋サバは能登以北では比較的好漁であつた（例えば，富山県魚津の10月上旬は，1,100貫の一本釣漁獲があり，27年の約3倍)。

特に著しい現象は，若狭湾〜兵庫県のサバ漁場は，スルメイカ・大羽イワシと共に漁場遠く(例年より5浬以上も沖合)，しかも若狭湾の秋サバは，游泳層も深く，一本釣で90〜100尋であつた。若狭湾における28年のサバは，春も仲々浮上しなかつたことが大きな特徴であり，例年比大不漁ながらも，とれた春サバ（巾着網）の大部分は，浮上しないもの，すなわち魚探巻きによるものであつた。しかも5,6月ごろ，体長10cm未満の小サバが，かつてない程定置網にワンサと入網したことも特異現象であり，春の小サバの大繁殖は28年の秋サバ・29年のサバ漁にも，特別の好漁をもたらしていない。

一般に若狭湾のサバは，隠岐島方面より1週間遅れとなるが，28年春のように，彼我豊凶の差が余にも大であると，隠岐島方面から来游して来るという当業者の考えが，ぐらついたりする。

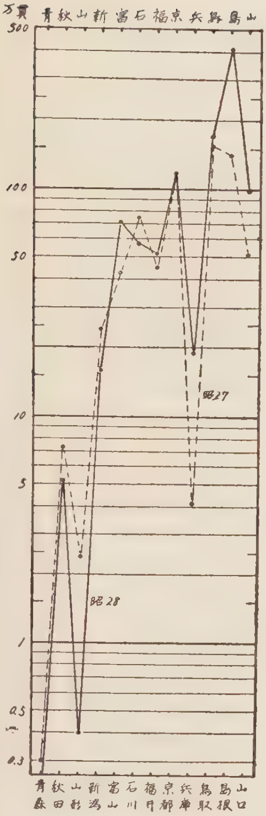
なお，隠岐島方面のサバの豊漁は，春秋共夜焚巾着網によるもので，昼巾着は不漁であつた。同方面の昼巾着網漁業は，昭和24年頃から本格的になつたものであり，昭和27年が最も好成績（推定900万貫）であつた。

アジ Horse mackerel

日本海のアジはマアジ *Trachurus trachurus* が大部分で，28年の総漁獲高は1,200万貫（全国6,376万貫の16%）で，マイワシ・サバに次ぐ第3位の魚種である。サバと同じく，新潟以西で大部分（99.5%）がとられるが，若狭湾を始めとするサバ巾着の大不漁にひきかえ，アジは対照的に大豊漁（1,019万貫，27年の1.5倍強）で，富山湾以西，ことに島根方面は中・小アジの近年にない大豊漁（漁期は4〜11月，28年総数413万貫で，27年の3倍）であつた。例えば，同県浜田では一函，木箱共25円という超安値さえ出た。又経ケ岬方面の

沿岸漁業者も，3月以来大漁続きであつたが，サバ不漁の巾着網船が，一本釣漁場に侵入して来るなどの悶着が非常に多かつた。ちなみに，若狭湾のアジは170万貫で，27年の2.2倍の豊漁であり，28年春のサバ巾着の漁獲のほとんどすべてが，アジであつた。

新潟県以北は27年より不漁（第9図）。兵庫県・新潟県方面の始漁は，それぞれ1旬，1カ月早かつた（一本釣）。



第9図　日本海アジ類の府県別・年別の年間漁獲高

カレイ類 Flounders

山口県の60万貫減の他は，各府県共27年より豊漁のため，日本海全体としては，27年より22万貫増の870万貫（全国3,173万貫の27,4%）となつた。カレイ類は西方程多獲される（第10図）が，100万貫以上は兵庫以西の4県であり，621万貫（71%）を占める。特に，山口・兵庫は各200万貫の水揚げがある。魚種別にみると，兵庫のマガレイ・ババガレイ（各80万貫），島根のムシガレイ（46万貫），石川・福井・鳥取のアカガレイ（各20～35万貫）が主なものである。

スルメイカ *Ommastrephes sloani pacificus*（第11図）

日本海のスルメイカは，津軽海峡西口・佐渡～能登・隠岐島を3大漁場とするが，28年は若狭湾を除いて，軒並みの不漁であり，ことに富山湾において甚だしく，27年の1/10という旬間漁獲高のこともあつた。結局日本海全体としては，27年の67%，784万貫に止まつた。これは全国11,202万貫の7%に当る。しかしスルメイカ以外のイカ類は，27年より豊漁で，5%増の428万貫であつた。

昭和27年12月以来大豊漁であつた，隠岐近海のスルメイカも，28年2月中旬に至つて終漁となつた。同期富山湾の冬イカは1か月遅れの始漁であつた。富山湾以北は不漁で，特に富山湾～新潟県の冬イカは不振を極め，盛漁期に当る1～3月の富山湾は，27年の1/6～1/8の旬間漁獲にすぎなかつた。夏イカの始漁は逆に1旬早く訪れたものの，7月の盛漁期に豊漁がみられず，結局28年を通じて，27年の25%，76万貫という不漁に終つた。一方山口県は7月に盛漁期に入り，7月上旬の漁獲約7万貫で，同旬総漁獲高の34%，27年の5倍という豊漁であつた。しかし冬イカ不振のため，年間通計は27年の40%に止まつた。

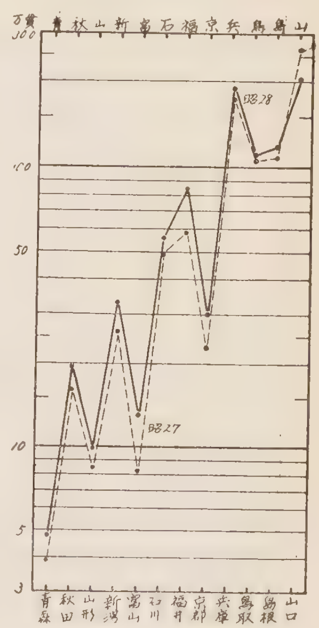
兵庫県方面の夏イカは，7～10日の遅れで，7月に入つてやつととれ出し（7月上旬5,300貫）ながらも，8～9月は今までにない豊漁であつたが，他の時期に振わず，結局年計において，27年の20%に止まつた。

兵庫県方面のスルメイカ漁の特徴：

i) 27年の夏イカは，70匁位に一定していたが，28年は40～70匁で一定していなかつた。

ii) 大羽イワシ・サバと共に，漁場が27年より5浬も沖合に形成された（距岸15浬以上）。8月中旬に至つてもなお，例年比5浬も沖合であつた。

8月下旬～9月上旬には，漁場は更に沖合に移り，一番沖合（距岸30～50浬）が魚体も一番大形（100匁）で，沿岸程小形（70～80



第10図　日本海カレイ類の府県別・年別の年間漁獲高

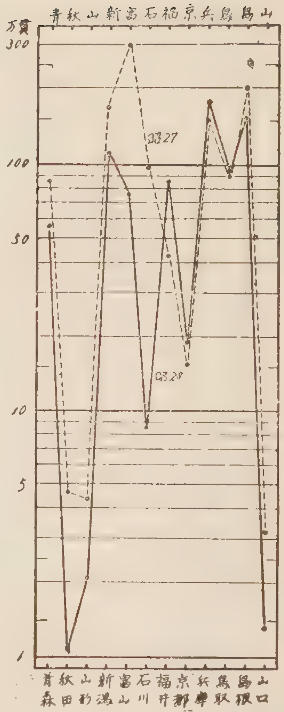
匁）であつた。以後９月中旬から沖合冷水域の接岸と共に，再び漁場は，時化毎に岸近くになつて来た。

兵庫県香住地方では，９月上旬の最盛期（9万貫）には，延1,887隻が出漁する盛況であつたが，同下旬を以て夏イカは終漁となつた。

秋田県八森方面の一本釣は，ほとんど全部100匁以上の，近年にない大形であつた。

ところで最大漁場である，隠岐近海の28年冬イカは，半月遅れで，12月12日に漸やく初漁があり，同日西郷1万貫（一本釣），浦郷4千貫（定置網3統）の漁であつた。そして12月中旬に至り，浦郷の総漁獲高16,000貫中14,000貫を占める程になつた。しかし，12月以降冬ブリと共に大不漁となり，一本釣の出漁は皆無となつた。すなわち旬間漁獲高は，27年冬の⅓〜⅙となつた。

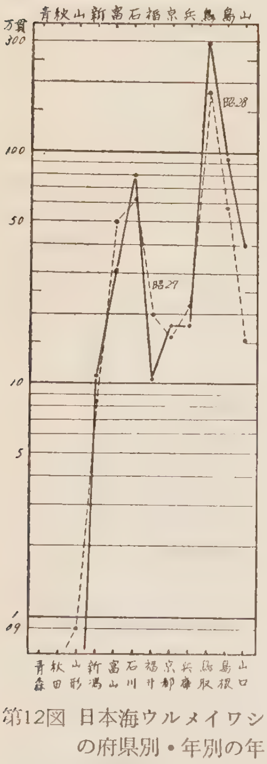
しかしてこの方面の特徴は，例年に比し，ムラ掛りが激しかつたことである。



第11図　日本海スルメイカの府県別・年別の年間漁獲高

ウルメイワシ *Etrmeus micropus*　（第12図）

ウルメイワシは，全く新潟県以西の魚種である。中でも鳥取県は，とび抜けて漁獲が多く日本海総数の50%，295万貫を水揚げする。日本海総数は596万貫で，全国1,400万貫の43%を占める。鳥取県の120万貫増を始め，以西海面での豊漁にもかかわらず，富山・福井等諸県の不漁により，日本海総数は27年並となつた。ウルメイワシが，晩春ないし初夏にとれ出すと，マイワシの漁は終りを告げる。



第12図　日本海ウルメイワシの府県別・年別の年間漁獲高

スケトウダラ *Theragra chalcogramma*　（第13図）

日本海における最多獲底魚で，佐渡・富山湾・加賀〜越前を主漁場とする。28年の漁獲で著しい現象は，富山湾（富山県）の大不漁（41万貫，27年の40%）と，兵庫県の大豊漁（221万貫，27年の22倍）であり，又福井県・兵庫県を除く各地の不漁である。このため日本海全体としては，27年並の265万貫（全国6,007万貫の9.4%）に止まつた。

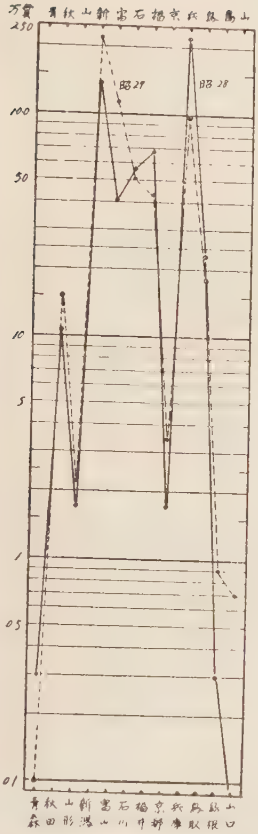
富山湾の大不漁は，５〜８月の大不漁が原因であり，例えば，同湾の北側にあつて，スケートダラ水揚の一中心地である，石川県宇出津の漁獲高は，27年同期の１割にも達せず，スケトウ延縄船は四艘張網漁業に転業するものが多かつた。そして富山湾は10月以降の秋漁期に，刺網がかなりの好漁を示したこともあつたが，春の大不漁はついに回復できなかつた。

不漁の新潟県でも，佐渡北岸のみは，夏漁は非常な好漁で，魚体も例年にない大形魚であつた。しかし秋漁期は，約１か月遅れとなり，10月が盛漁期（10万貫）となつて，魚体も小形で，引続き不漁であつた。

一方福井県〜鳥取県の沿岸は好漁で，特に３〜５月にわたる，兵庫県沿岸の底曳網は盛況で，27年の３倍以上の大漁であつた。すなわちこの3か月間で，兵庫県年間漁獲221万貫の90%，193万貫を水揚げした。

兵庫県沿岸（100尋線）が，スケトウダラの主要漁場であるのは奇異の感であるが，ここでは戦前ほとんどとれず，僅かに隠岐方面に細々と出漁しているにすぎなかつた。又小形魚のみであつたが，昭和26年頃から，香住を中心とする地先でとれ出し，27年からは本格的漁業となつたnew faceである。

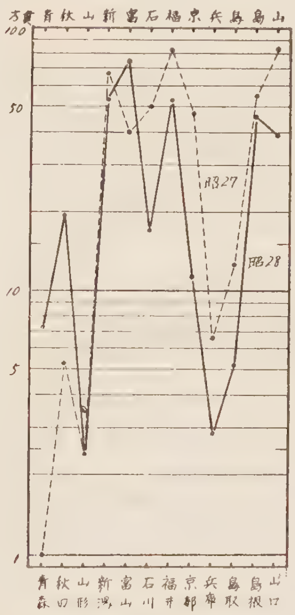
現在の漁場は，香住沖15〜20浬の陸棚縁辺である。



第13図　日本海スケトウダラの府県別・年別の年間漁獲高

ブリ *Seriola quinqueradiata*（第14図）

ブリは入道崎・佐渡〜若狭湾・島根県以西を主漁場とするが，28年は，富山湾以北は好漁，能登以西不漁で，結局日本海全体としては，27年の73％（331万貫，全国1,295万貫の25.6％）の不漁に終つた。



第14図　日本海ブリの府県別・年別の年間漁獲高

富山湾氷見方面を除いて，各地共漁期は非常に遅く，或はほとんど来游がなかつたりした。

4〜7月の夏ブリ（600匁〜1貫の魚体）は，山形県以北では，定置網に比較的好漁，特に秋田県では8月に豊漁であつた（27年の4倍，20万貫)。新潟県では，小形イナダ類は好漁であつたが，定置網は大不漁。若狭湾は，1か月遅れの7月にやつと定置網にとれ出したが，7月一杯にわたつて，400匁以下のフクラギの大漁が続き，沿岸各地で，一網何万貫という好漁があり，氷の不足に悩んだ程であつた。

しかし冬ブリ（4〜5才，2〜3貫）は，日本海全般にわたつて不漁で，特に能登半島・隠岐島方面で甚しかつた。例えば，隠岐島の12月は，27年同期の⅓〜¼という旬間漁獲高で，28年に戦後はじめて操業した餌付漁業も，ほとんど漁獲がなかつた。しかし代つて，10〜11月に，曳釣によつて小マグロが多獲された。

一方富山湾・佐渡両津湾における，10〜11月の小ブリは好漁で，富山湾の如きは，27年同期の3〜5倍の豊漁であつた。この小ブりの好漁によつて，大形ブリの不漁を補つて余りがあり，結局年間64万貫となつて，27年の2.7倍強の好漁となつた。

アブラツノザメ *Squalus suckleyi*（第15図）

アブラツノザメは，日本海産サメ類の大宗をなす魚種であり，北部日本海の重要漁獲対象である。主として新潟以北でとられるが，28年は，青森を除き軒並みに不漁であつた。日本海総数は，27年より40万貫減の199万貫（全国953万貫の21％）の不漁となつた。

新潟〜石川は来游早く（新潟は3月中旬に初漁），山形は遅く，しかも延縄によるものは，例年♀が大半であるが，28年は逆に♂が大半を占めた。能登半島西岸は，27年と同様に大不漁で，ムラ掛りが激しかつた。新潟県の漁場は佐渡沖合であるが，28年は魚群濃厚であつたにもかかわらず，漁期は短かかつた。

京都・兵庫方面は，大体平年並の漁獲であつたが，他は全般的に不漁で，特に3〜4月が香ばしくなかつた。

小形マグロ

青森県・秋田県の夏定置網；島根県・山口県の曳縄釣は好漁であつたが，新潟県〜鳥取県の定置網・曳縄釣は，全般的に不漁であつた。又兵庫県の始漁は早く，11月上旬であつたが（曳縄釣），新潟県は非常に遅れ

た。

一方冬ブリの大不漁に見舞われた隠岐島では，10～11月に，代つて小マグロばかりが，多獲された（曳釣）。

Ⅳ　その他の魚種

ここには，地方的に重要なものについて述べることとする。

ハタハタ *Arctoscopus japonicus*（第16図）

主として底曳網でとられ，28年の日本海総数は，191万貫で，全国284万貫の67%を占める。島根県以西では，ほとんどとれない北方種である。

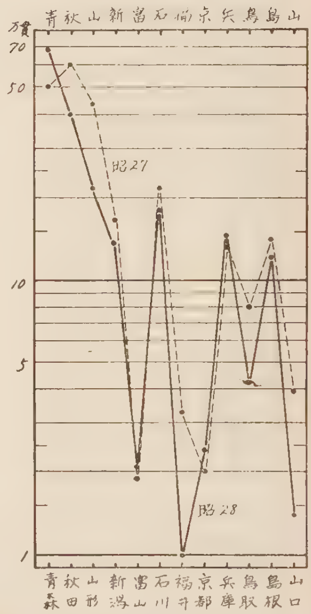
能登以北及び兵庫県は，この10年来にない大豊漁で，例えば秋田県（定置網）は67万貫で，27年の3倍強であつた。一般に漁期が早く始まり，特に石川県金石では，例年より100日余も早く，27年12月下旬からとれ出し，例年始漁となる3月に入ると共に，終漁となつた。

又兵庫県・新潟県を始め，比較的大形魚であつた。

マス Cherry-salmon（第17図）

日本海のマスは，サクラマス *Onchorhynchus masou* であり，能登以北でとれる。特に青森・秋田・新潟を主漁場とする。28年の総漁獲は，27年比5,000貫増の9万貫（全国467万貫の2%）であつた。

山形県～石川県の初漁は，1旬～半月早かつた（一本釣・毛釣・落網)。能登西岸では，2月下旬，毛釣のものは，100～500匁の魚体であつた。

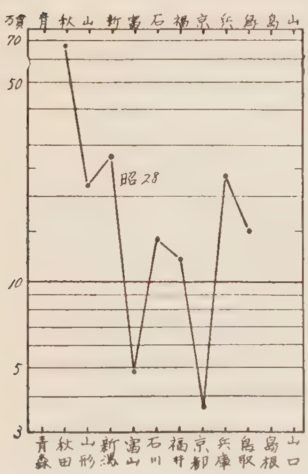


第15図　日本海アブラツノザメの府県別・年別の年間漁獲高

サケ Salmon（第18図）

日本海のサケは，*Onchorhynchus keta* であるが，新潟県以北，ことに新潟県を主漁場（ふつう3万貫）とする。各地共，27年より不漁で，27年の60%，4.2万貫（全国288万貫の1.5%）にすぎなかつた。

新潟県沿岸の定置網漁は，1旬遅れの11月中旬に初漁となつた。例年比小形で，300～700匁の魚体が多かつた。



第16図　日本海ハタハタの府県別漁獲高

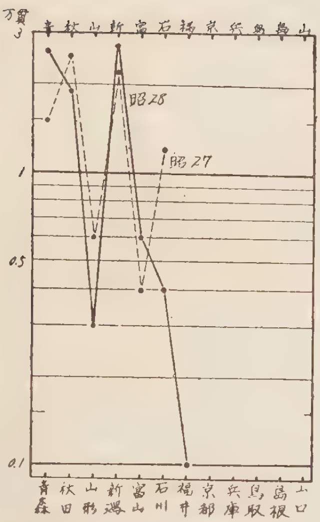
シイラ *Coryphaena hippurus*

全国140万貫の40%，56万貫の年間漁獲であつた。シイラは6～11月を漁期とするが，8～9月を盛漁期とする。日本海西区は51万貫で，北区の11倍である。暖海性魚種で，秋田県入道崎を以て，シイラ漬漁業の北限とする。島根県（24万〆)，鳥取県（10万貫）が，とび抜けて多い。27年より豊漁。ただし，兵庫～隠岐は不漁であつた。

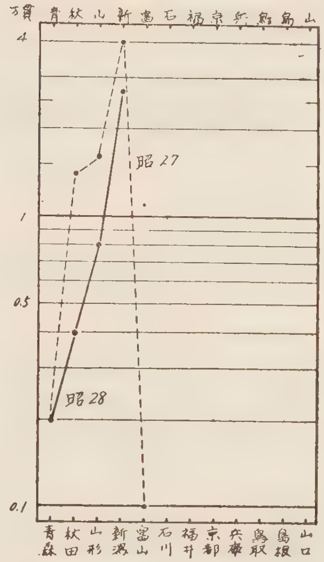
新潟県の漁場は，平年比沖合に形成され，かつ不漁であつた。しかし魚体は大きかつた。

イカナゴ *Ammodytes personatus*

全国1,755万貫の僅か9%，16万貫にすぎないが，内10万貫は福井県で占め，他は秋田の4万貫，山形の1万貫が目ぼしい。山形県ではふつうほと



第17図　日本海マスの府県別・年別の年間漁獲高



第18図　日本海サケの府県別・年別の年間漁獲高

んどとれないが，28年は由良沖で，40年ぶりにバンバラ（大形イカナゴ）がとれた（底曳網）。

ニギス *Argentina kagoshimae*

全国185万貫の76%，141万貫の漁獲高を示したが，西区は北区の3倍以上の110万貫，内69万貫は兵庫県の水揚高である。主漁場は島根県浜田・見島方面であるが，やや遅れて10月下旬に初漁となつた。

ホツケ *Pleurogrammus azonus*

ホツケは能登以北のみにとれる魚であり，28年の総数46万貫（全国4,226万貫の1%）中，青森県23万貫，秋田県15万貫で大部分を占める。

秋田県方面では始漁早く，かつ豊漁であつた（魚体150匁大）。

メバル

石川県の始漁は半月早かつた。

タラ *Gadus macrocephalus*

タラは日本海全体にとれるが，秋田県～島根県を主漁場とする（定置網）。富山県以北は27年並，或は以上であつたが，石川県以西はすべて著しい不漁であつた。年計は27年の45%，70万貫（全国741万貫の9.3%）の不振となつた。28年は全国的に不振で，全国総漁獲も，27年より250万貫の減となつた。

秋田県のみは，1か月早く，1月上旬から始漁となつたが，他は各地共遅れた。新潟県を除き全般的に不漁で，石川県では小形魚ばかりであつた（3月上旬終漁）。

モウカザメ *Isurus nasus*

日本海では，ほとんど全部青森県と石川県でとれるが，日本海28年の総数は，27年の60%，5万貫（全国171万貫の3%）という不漁であつた。

石川県は，27年より1旬早い始漁であつたが（延縄），アブラツノザメと同じく，ムラ掛りが甚だしかつた。

ヒラガシラ *Scoliodon walbeehmi*

肝油原料として重要な，隠岐島のヒラガシラは，ふつう6月で終漁となるが，28年は7月一杯までとれた。7月中旬2,500貫（底延縄）。

ズワイガニ *Chionoecetes phalangium*

各地共豊漁であつた（第19図）。ズワイガニは，日本では日本海のみにとれる漁獲対象である。山形県～島根県にわたつてとれるが，福井・兵庫・鳥取の3県を以て主産地とする（日本海全体の76%，152万貫）。日本海全体は200万貫を越す大豊漁で，27年の約7倍の漁獲であつた。

隠岐島の初漁はやや遅れて，12月上旬であつた。

ホタルイカ *Watasenia scintillans*

富山湾特産のホタルイカは，27年より1週間遅れの3月中旬であつた（魚津，定置網）。

ワカメ *Undaria pinnatifida*

隠岐島では生育悪く，採草期を遅らせて，6月上旬からとした。不漁で27年の½。

V　若狭湾の特記現象

28年春からの現象であるが，漁業者もこれをで見たことのないような，次のような暖海性動物が見られた（福井県水産試験場長東田勇氏からの通報）。

スギ *Rachycentron canadum*

　多数のスケトウダラと共に，定置網に入網した（半ノ浦・日向）。

ギンカガミ *Mene maculata*

アンコーウバウオ *Apasma laticephala*

　共に定置網に入網（丹生）。

ツムブリ *Elagatis bipinnulata*

　釣獲された。

アシカ *Eumetopias bobatus*

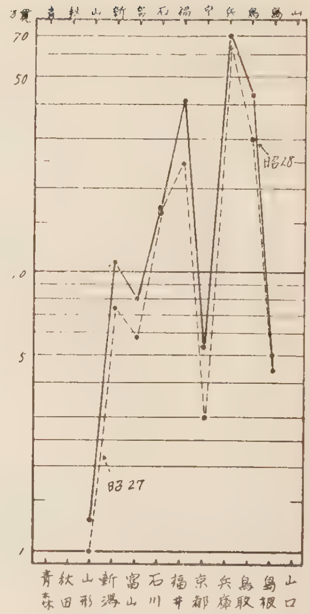
　敦賀湾松島海岸に上陸

又若狭湾の湾口に位置する，京都府下宇川村でも次のようなものが見られた。

　ツムブリ

　エビラウナギ

　キワダ



第19図 日本海ズワイガニの府県別・年別の年間漁獲高

昭和29年日本海漁況の経過

(1954年1月～12月)

下　村　敏　正

A General Review of the Japan Sea's Fishing Conditions in the Year 1954

by

Toshimasa SHIMOMURA

I　漁況の大要

「昭和29年海面漁業漁獲統計」一農林省統計調査部一によると，29年（1～12月，以下同じ）の全国総数は約124,000万貫で，昭和20年45,000万貫の谷から急速に立ち直つていることが判る。27年に至つて戦前の水準を突破しているが，27年以来頭打ちの状態となつている。日本本土を基地として操業する一般海面漁業では，ニシン・マイワシ・イカなどの重要魚種は著しい減少を示し，逆に母船式漁業による漁獲物は急増し，総体として平衡を保つているのが現状である。

こうした一般状勢の中で，29年の日本海総漁獲高は15,480万〆（魚介藻類などを含めて）で，28年より1,900万〆の増であるが，これは全く魚類の漁獲増に基くものである。

日本海総数は，全国総数の16%に当り，28年の12%よりも増大している。この原因は他海区における春ニシンとマイワシの大不漁にもかかわらず，北部日本海におけるマイワシ，鳥取におけるサバの大漁である。

日本海の海区別にみれば，日本海総数15,480万〆の73%（11,247万〆）は，福井～山口の日本海西区の漁獲である。すなわち，西区は北区（石川～青森）の3倍以上であるが，28年における北区の25.6%からみると，北区の比重が1.5%上昇している。これはやはり北区における大羽イワシの豊漁に基因している。そして西区がかかる高比重を示すことは，島根・鳥取・山口と，それぞれ2,000万〆以上の県を持つためであり，ことに山口県日本海側の4,770万〆（28年比760万〆増）という，北区の総数を上まわる，ぼう大な水揚高がその主因である。

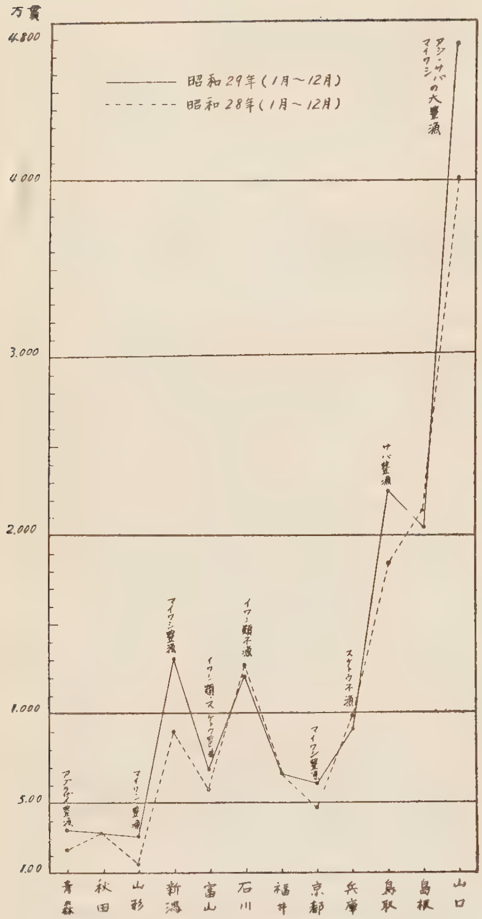
山口のこの大漁は26年以後の頭打ちが，29年に至つて見島沖に，アジ・サバのぼう大な来遊があり，旋網漁業が集中的に操業されたのが主因である。すなわちアジは，8月（128万〆）・11月（106万〆一28年11月の9倍）を山とする周年にわたる豊漁，サバは，11月の220万〆（28年11月の48倍）を山とする周年にわたる豊漁に因るものである。要するにアジ・サバは，山口県として戦後の最高記録を作り，アジ551万〆・サバ463万〆計1,014万〆で総漁獲高の21%を占めた。

今府県別に総漁獲高を示すと第1図となるが，これを階層別にみると，次のように，一般的に云つて，例年のとおり南方程漁獲高が多い。これは漁獲対象物の多いこと，またイワシ類・アジ類・サバ類・底曳漁獲物の

500万〆以下	青森・秋田・山形
1,000万〃以下	富山・福井・京都・兵庫
2,000万〃以下	新潟・石川
2,000万〃以上	鳥取・島根・山口

大量なことに因る。28年と異るのは，京都・鳥取・新潟がそれぞれ一階層上り，兵庫が逆に一階層下つたことである。これら府県別の昇降の主たる原因は次のようである。

京都：マイワシ	＋120万〆
鳥取：サバ	＋450〃
新潟：マイワシ	＋290〃



第 1 図　昭和29年府県別総漁獲高

兵庫 ： スケトウダラ　　　— 95 〃

ほかに山口は，28年比 760 万〆増の大漁となつているが，次のように，特にアジ・イワシ類の大豊漁が主原因である。

アジ　　＋450万〆
マイワシ　＋200 〃
サバ　　＋ 45 〃

日本海全体を通じてみた場合，総数15,480万〆の内，500万〆以上の主要漁獲物は，次の 7 種であり，これだけで日本海総数の61%，9,456万〆を占める。この内キグチは，山口県（下関漁港）にのみ水揚げされる，日本海としては，特殊の魚種である。

魚　種	日本海総数	日本海総漁獲高に対する比	昭和28年比
マイワシ	3,189万〆	20.6%	＋804万〆
サバ	2,420 〃	15.6〃	＋926 〃
アジ	1,450 〃	9.4〃	＋431 〃
スルメイカ	746 〃	4.8〃	— 38 〃
ウルメイワシ	573 〃	3.7〃	— 24 〃
キグチ	565 〃	3.7〃	— 36 〃
スケトウダラ	513 〃	3.3〃	— 52 〃
計	9,456 〃	61.0〃	

日本海北区・西区の主要魚種・主要漁具は第 2 図に示すとおりであるが，28年に比し，漁獲高の増減した主な物は，上表最右欄のとおりである。ほかに減少の主なものとしては

ブリ　　250万〆　—80万〆
スルメイカ以外のイカ　365 〃　—63 〃

全国総数の月別推移が，春と秋とに山らしい山を持つのに対し，日本海総数のそれは，5 月と11月とに著しく孤立した山を持つ（第 3 図）。しかもこの 2 つの山は，28年に比べて次のように著しく高いのである。また 2 つ

5月 ： 28年比 36 % 増（2,454万〆）
11月 ： 28年比 88 % 増（1,773万〆）

の山は，28年に比べてそれぞれ 1 カ月遅れとなつている。

5 月の山が28年に比べて著しい変化を示すのは，

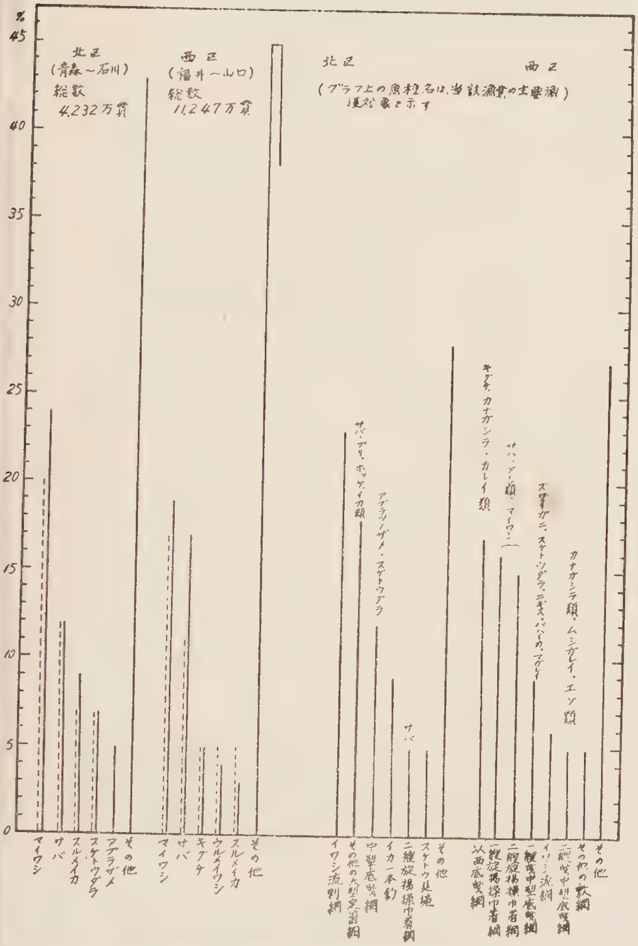
i) 西区の最盛期が，28年の 4 月よりも 1 カ月遅れの 5 月となり，かつ漁獲高も70万〆増したこと。
ii) 北区の最盛期は，28年と同様に 5 月であつたが，28年の52%増（1,175万〆）となつたこと。

が原因であり，11月のそれは，

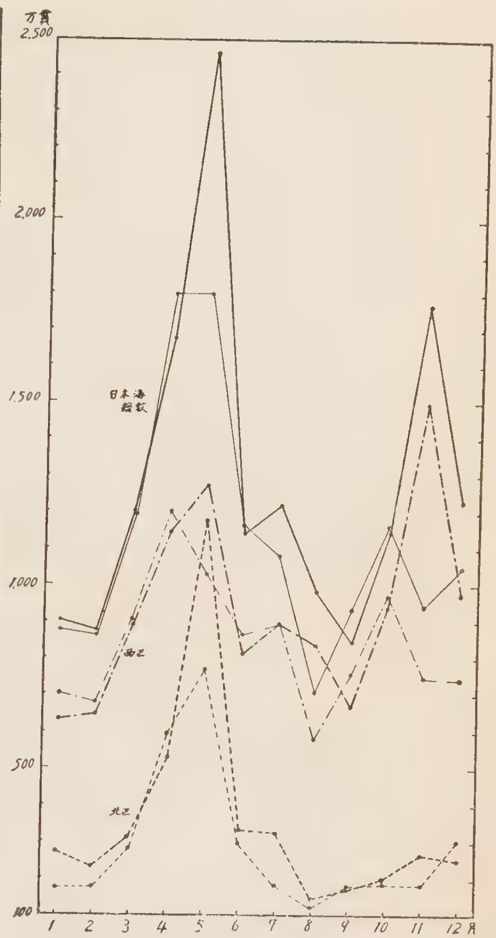
西区・北区共に秋の最盛期が 1 カ月遅れの11月となり，しかも両区共に，とくに西区において大豊漁（98%余増の1,504万〆）を示したこと。

が原因である。

漁獲の谷は，例年のとおり冬と夏との 2 回あるが，最盛期の 1 カ月遅れに対応して，夏枯れ期もまた 1 カ月遅れの 8 月となつている。しかも夏枯れ時の漁獲高も28年より好漁となつている。このように夏枯れの谷が上昇したということは，山口県の夏枯れ期の解消ということが大きく影響している。すなわち山口の生産高は日本海総数の30%余という大きな比重を持つているが，この同年変化は，下関を基地とする以西トロール・以西



第２図　昭和29年日本海海区別の主要魚種及び主要漁業



第３図　日本海総漁獲高の月別推移
（太線は　昭和29年
　細線は　昭和28年）

機船底曳網の周年変化によつて支配されている。それは，これらの以西漁業は山口の総数の½を占める高比重であることが原因である。したがつて山口の総数の周年変化は，底曳漁業の休漁期である８月を底として，春•秋が山となつている。これが例年のカーブである。しかるに29年には，このような周年変化カーブが消滅しているというより，むしろ逆に春•秋と並んで山（413万〆）となつている。29年に初めてみられる現象である。これは既記の如く，夏期における見島周辺のアジ•サバ旋網漁業の集中的操業によるアジの８月大豊漁（128万〆）及び沿岸における縫切網（小•中羽イワシ）の増大豊漁が二大原因となつている。

かように29年の日本海は周年にわたつて，28年より好漁に経過しており，その結果が総数において2,000万〆近い豊漁となつている。

一方５月の山で著しく目立つことは，北区の漁獲高が西区のそれと比肩する位の大漁を示していることであり，かかる現象は従来見られなかつたことである。すなわち，一般に西区の月間漁獲高は，常に600万〆以上であるが，北区では350万〆以下であることをみれば，５月の1,200万〆近い漁獲がいかに好漁であるかが判るであろう。

今５月の山を北区•西区に分けて，主要魚種５つを拾い上げ，28年と比較すれば次表となる。すなわち，北日本海はマイワシ一本で，５月の山が作られていることが判る。これに対し西日本海の山は，単一魚種に因る

魚種	29年5月総数	28年比	主たる生産県(万〆)
(北区)			
マイワシ	765万〆	+106%	新潟369, 山形153, 石川140, 秋田102
カタクチイワシ	72 〃	+ 16〃	富山61
スケトウダラ	54 〃	+ 32〃	新潟24, 富山20
スルメイカ以外のイカ	32 〃	+ 18〃	富山29 (ホタルイカが主)
スルメイカ	10 〃	+150〃	新潟 9
(西区)			
サバ	237 〃	+ 72〃	鳥取142, 島根55, 山口25
マイワシ	193 〃	+ 80〃	京都64, 山口56, 島根53, 鳥取12
アジ	193 〃	+ 47〃	島根82, 山口63, 鳥取32
ウルメイワシ	93 〃	+ 37〃	島根39, 鳥取35
カタクチイワシ	58 〃	+ 42〃	山口29, 京都13, 島根10

ものではなく，各重要魚種の軒並みの好漁に因つて作られている。

次に11月の山を見ると，次表となる。すなわち，日本海における一般的の重要魚種が，足並みをそろえて28

魚種	29年11月総数	28年比	主たる生産県(万〆)
(北区)			
サバ	23万〆	3.3倍	新潟15
ブリ	19 〃	$\frac{1}{3}$	富山10, 石川6
スケトウダラ	15 〃	2.8倍	新潟13
スルメイカ	14 〃	2.2〃	青森12
アジ	12 〃	6〃	新潟6, 石川5
(西区)			
サバ	674 〃	3.7〃	鳥取394, 山口220, 島根58
アジ	168 〃	2.3〃	山口106, 島根35
マイワシ	80 〃	2 〃	島根36, 鳥取15, 京都11
ウルメイワシ	21 〃	5 〃	山口10, 島根8
スルメイカ	19 〃	10 〃	鳥取23, 島根10

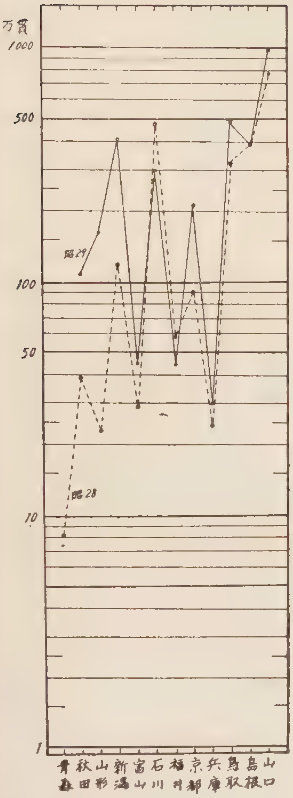
年よりも好漁となつているのが，11月の山の原因となつている。ことに西区一特に鳥取・島根・山口一におけるサバ・アジの好漁が，日本海全体の11月の山の主因をなしていることが判る。

II 主要魚種の漁況

マイワシ *Sardinia melanosticta* (第4図)

29年のマイワシの日本海総漁獲高は 3,200万〆（全国 6,550万〆の49%）で，28年比 804万〆の増である。しかも全国総数 6,550万〆の49%という高比率を示したことは，この年の全国的な不漁にもかかわらず，日本海がいかに好漁であつたか判る。日本海では福井の14万〆減を除いては，各府県とも28年よりも好漁となつている。全体として北区32%，西区68%で，28年の北区29%よりも3%増であるが，これは北区の漁獲高が28年比 1,026万〆（28年の1.5倍），特に次表のように，秋田・山形・新潟3県の好漁に基いている。すなわち，石川が平年漁400万〆を下回る不漁にもかかわらず，北区としては28年比335万〆の増となつた。しかも月間漁獲高としては，北・西両区を通ずる年間の最高数である。西区でも，福井の15万〆減を除き各地共増加しているが，特に上表のように，京都・鳥取・山口の好漁が，結局西区全体として28年比 470万〆（+28%）の増となつた。

北区のイワシ漁は，例年5月（大羽イワシ）に盛期となるが，29年も又その例に洩れず5月だけで年間総数の75%（765万〆）をあげている。これに反し，西区では29年には，200 万〆以上の最盛期が例年より前後に1カ月ずつ延びて5〜8月となつた。もちろんこれは，見島以西沿岸部（山口）の抄網による小・中羽イワシ



第４図　日本海マイワシの府県別・年別の年間漁獲高

		29年総数(万〆)	28　年　比	
北区	青　森	0.1	½	倍
	秋　田	107	3	〃
	山　形	163	7	〃
	新　潟	411	3.5	〃
	富　山	45	1.6	〃
	石　川	300	⅔	〃
西区	福　井	44	¾	〃
	京　都	216	1.3	〃
	兵　庫	30	1.3	〃
	鳥　取	488	1.5	〃
	島　根	393	変らず	
	山　口	992	1.3	〃

の漁期が長かつたこと，及び好漁であつたことに因る。そしてこれが12～4月の大羽漁の＋60万〆と相俟つて，西区全体として500万〆近い好漁となつたのである。

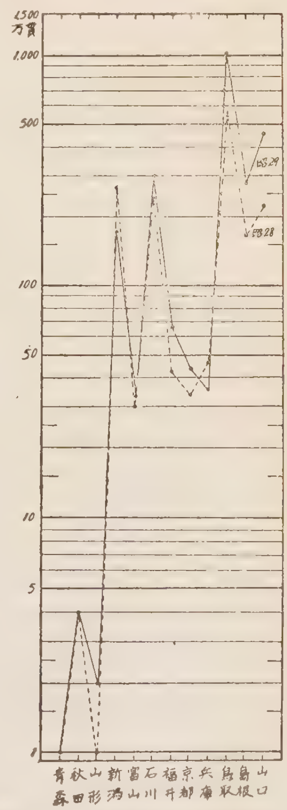
数量的には山口の201万〆増が最も著しいのであるが，これは29年に至つて縫切網（５トン以下の小型船）が急激に増大したためであり，しかも６～11月の夏期を中心とする時期に，連続操業をされたためであり，この小・中羽の大漁が冬期流刺網による大羽イワシ漁の平年作に添加されたのである。

サ　バ *Scomber japonicus*（第５図）

日本海のサバは *Scomber japonicus* を主体とする，新潟以西の魚である。従来は佐渡島・能登半島・若狭湾・隠岐島を四大漁場としたのであるが，この内若狭湾は昭和25年の豊漁を最後として凋落を続け，29年は80万〆（福井＋京都）にすぎず，25年生産量の$\frac{1}{10}$という不漁である。

29年における日本海総数は 2,420万〆（全国 7,931万〆の31％）で，マイワシに次ぐ重要漁であり，28年比 925万〆増（＋16％）となつた。一面これは，28年の全国比24％に比べ大きな比重増である。そしてこの日本海の好漁は，李ラインの強化による済州島漁場の操業の潰滅，北海道釧路沖漁場における夏サバ漁の皆無など，他海域の不漁を補つて余りがあり，全国総数の28年比 1,700万〆（26％）増の原動力となつている。日本海のこの好漁は，日本海に府県の軒並みの好漁に因つているが，とくに鳥取沖（隠岐南～南東漁場）の未曽有の好漁（ 1,021万〆―28年の約２倍）に最大原因がある。鳥取沖でのこの好漁は，６月を除く29年の年間を通ずる好漁にも因るが，何と言つても11月における 395万〆という好漁に起因している。これらのため，鳥取県始まつて以来の大豊漁であつた28年を，さらに上回る大豊漁となつた。この11月という月を中心にして，島根・山口も非常な好漁を示し，島根・山口の28年の秋サバの不漁を一挙に回復した。

サバの日本海総数 2,420万〆の内，北区は21％の 515万〆，西区は79％ 1,905万〆を占める。100万〆以上は次の５県である。



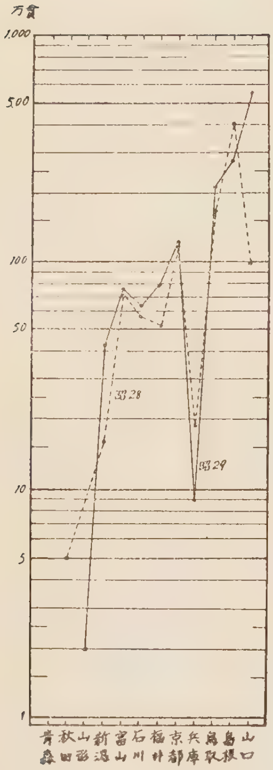
第５図　日本海サバの府県別・年別の年間漁獲高

府県名	29年総数	28年比
新潟	172万〆	＋ 40%
石川	303 〃	＋ 150〃
鳥取	1,021 〃	＋ 100〃
島根	274 〃	＋ 60〃
山口	463 〃	＋ 100〃

アジ Horse mackerel　(第6図)

日本海のアジは，*Trachurus trachurus* を主体とする，新潟とくに京都以西の魚である。日本海ではマイワシ・サバに次ぐ重要魚種であり，29年総数は 1,450万〆で，28年比 431万〆（42%）の増となつた。アジ類は全国的歩調に合わせて，日本海でも27年来増加しつつあるが，若狭湾でもサバの不漁に代つて，アジは遂年増加しつつある。

全国総数は6,600万〆で，28年比300万〆（4％）の増となつているが，アジも又サバと同様に対馬暖流域の好漁が全国的好漁の最大原因となつている。このことは，日本海総数が全国総数の22%を占め，28年の16%よりも比重が大きくなつたことにも窺われる。日本海総数 1,450万〆の内，西区は90%（1,263万〆）を占めるが，これは次の4府県の好漁に基いている。



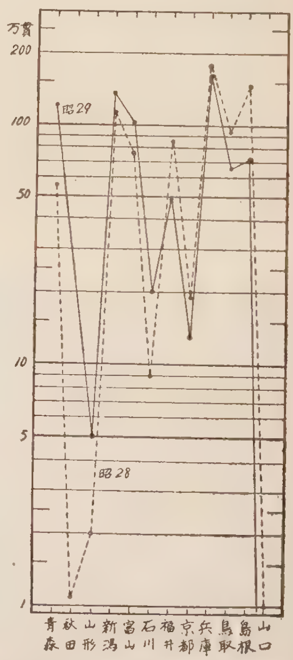
第6図　日本海アジ類の府県別・年別の年間漁獲高

府県名	29年総数	28年比
京都	122万〆	＋ 5%
鳥取	218 〃	＋ 28〃
島根	283 〃	－ 32〃
山口	551 〃	＋ 460〃

スルメイカ *Ommastrephes sloani pacificus*　(第7図)

日本海のスルメイカは，津軽海峡西口・佐渡〜能登・隠岐島を3大漁場とするが，29年は，28年が若狭湾を除いて一律に不漁であつたのに対し，本年は北区では漁が回復して，各県共28年よりも好漁となり，北区だけで，28年比125万〆増（約50%増）の381万〆となつた。これに反し，西区では若狭湾・隠岐島共に不漁，とくに鳥取・島根の半減という不漁のため，結局西区全体としては，28年の165万〆減（31%減）の364万〆という不漁になつた。すなわち，北区は日本海総数746万〆（28年は784万〆）の51%強となり，西区・北区その位置を転倒するに至つた。これは，6〜7月における新潟・富山（共に一本釣が大部分で，次いで定置網による漁獲）の好漁・青森の7月・9〜11月の好漁に因る。

全国的にみて，スルメイカは27年以来減少の傾向があり，29年は夏イカが例年にない好漁で，しかも夏漁期が長期にわたつて好漁であつたが，年間漁獲高を決定する，肝心の10〜12月の秋イカが道南海区漁場と青森県北部海区漁場が不振のため，結局28年比500万〆（6％）減の 10,600万〆となつた。この 600万〆減の中には，日本海の38万〆減も含まれているわけであるが，日本海総数 746万〆の全国総数に対する比率は，28年と同様に7％となつている。



第7図　日本海スルメイカの府県別・年別の年間漁獲高

今，年間100万〆以上の主な生産県をあげると，次の4県となる。

県　　名	29年総数	28年比
青　　森	121万〆	＋120%
新　　潟	134 〃	＋ 20〃
富　　山	102 〃	＋ 40〃
兵　　庫	164 〃	－ 8〃

スルメイカ以外のイカ類

スルメイカ以外のイカ類もスルメイカと同様に，全国的にも，日本海としても，共に減少している。下表からも判るように，

	29年漁獲高	28年比
全国総数	1,188万〆	－88万〆(－7%)
日本海総数	365 〃	－58 〃(－15〃)

日本海の減少は全国総数の減少の過半数を占めている。

しかし一方日本海の内，北区だけについてみると，その漁獲高は28年よりも好漁（37万〆増—42%—の 125万〆）であるのに対し，西区では不漁（100万〆減の240万〆）となつている。この北豊・西凶の現象は，スルメイカの場合と全く同様である。日本海全体としての不漁は，西区特に山口の，28年比62万〆減（122万〆）という大不漁が因をなしているが，これはもつぱら，一本釣による６～８月のケンサキイカ及び以西底曳網による10～12月のコウイカの不漁のためである。

又北区の豊漁は，青森～石川６県の軒並みの好漁にも因るが，何と言つても富山湾特産ホタルイカの漁獲高65万〆という戦後最高の数字である。29年は28年比26万〆（68%）の増である。すなわち，28年は非常な不漁であつたが，29年は順調な漁期となり，４～５月で年間の81%（53万〆）を漁獲した。漁具はイワシ定置網を主とし，次いでホタルイカ定置網であるが，両漁具の漁獲の割合は大体３：１となる。

ウルメイワシ *Etrumeus micropus*　（第８図）

イカ類と同様に全国的にも，日本海総体としても減産している。全国総数に対する日本海総数の比は45%にも達するが，同じ日本海でも北区・西区に

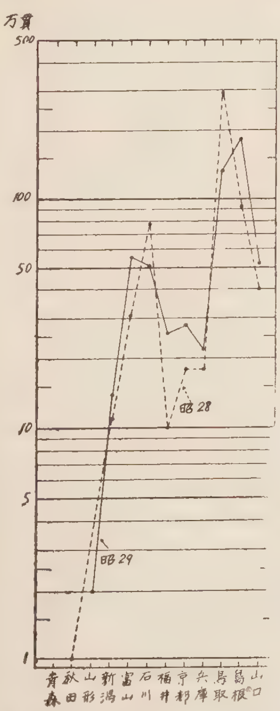
	29年漁獲高	28年比
全国総数	1,280万〆	－120万〆(－8.6%)
日本海総数	573 〃	－ 23 〃 (－4 〃)

分けて考えると，北区の増産（123万〆で28年比＋1.5%）に対し，西区は減産（450万〆で25万〆減）となつていて，これが日本海総数の減少の因をなしている。この北豊・西凶はイカ類と同じ現象である。

ウルメイワシは新潟以西の魚種であり，特に鳥取・島根をその中心とする。一般に各地共28年比好漁となつているにかかわらず，石川，鳥取両県の，特に

県　　名	29年総数	28年比
石　　川	51万〆	－ 29万〆（—36%）
鳥　　取	132 〃	－163 〃（—55%）

鳥取の大不漁が，日本海総数の減少の原動力をなしている。特に28年の鳥取は，この一県のみで 295万〆という，日本海総数の50%を占める大漁であつたが，29年は28年の23%にすぎない凋落である。すなわち29年は，鳥取のウルメ資源が新潟以西の各府県に分配されたというかつこうになつており，その首位を島根（190万〆，28年の２倍強）に奪われた。鳥取の大不漁は４～７月における，28年の$\frac{1}{5}$（７月）というような凶漁の続いたのが原因である。



第８図　日本海ウルメイワシの府県別・年別の年間漁獲高

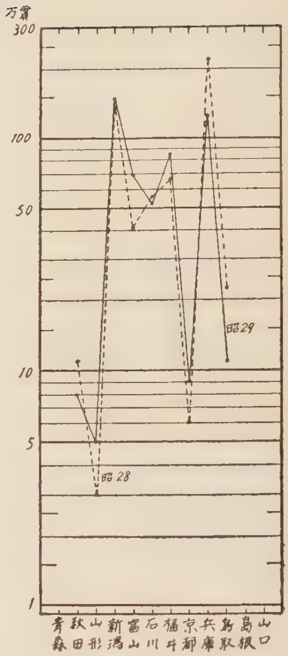
スケトウダラ *Theragra chalcogramma*　（第９図）

新潟～鳥取の，いわば中部日本海の魚種であり，山口には全く漁獲されない。全国総数の増加傾向（28年比430万〆増の6,435万〆）とは逆に，日本海全体としては減少した（52万〆減の513万〆）。全国総数に対する日本海総数の割合は８%にも満たず，28年よりもさらに１%少くなつた。

しかし，例によつて日本海を北・西両区に分けてみると，北区は28年比35万〆（11%）増の 282万〆と好漁を示したにかかわらず，西区では不漁で86万〆（27%）減の 231万〆に止まつた。両区の漁獲高比は，北区55%となり28年の44%から大巾に比重を増している。すなわちイカ類・ウルメイワシなどと同じく北豊・西凶の漁獲である。

北区の好漁は，2～3月，10～12月の好漁による，新潟の年間10万〆増の147万〆が大きな原因をなしている。一方西区の不漁は福井・京都の好漁にもかかわらず，兵庫・鳥取，ことに兵庫の不漁が原因となつている。すなわち兵庫は28年比96万〆（43%）減の 125万〆に凋落したのであるが，これは28年好漁の主因をなした3～5月の盛漁期における，底曳網漁業の29年同期における不振に基いている。

しかし，いずれにしても日本海の漁獲の山は，全国総数の場合と同様に4月にある。

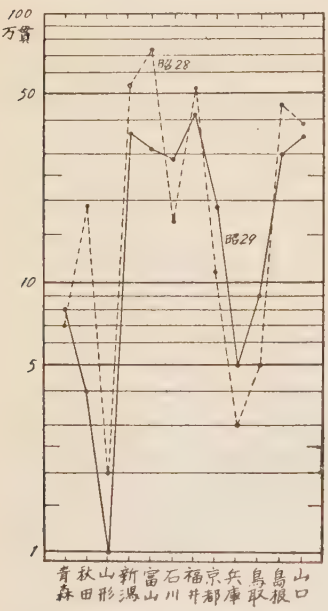


第9図　日本海スケトウダラの府県別・年別の年間漁獲高

ブリ *Seriola quiqueradiata*

（第10図）

全国総数における28年比58万〆減（1,237万〆）に対し，日本海総数は81万〆（250万〆）と，日本海の不漁は甚だしく大きい。全国総数に対する日本海の総数も，28年の26%から20%に下つた。日本海総数のこの不漁は，北・西両区の不漁に因るが，特に北区において甚だしい。



第10図　日本海ブリの府県別・年別の年間漁獲高

海　区	29年総数	28　年　比
日本海北区	110万〆	−64万〆　(−37%)
日本海西区	140 〃	−17 〃　(−12〃)

両区の日本海総数に対する割合は下表のように，28年とは逆になつた。

北　区	36.7%	52.5%	44%
西　区	63.3〃	47.5〃	56〃

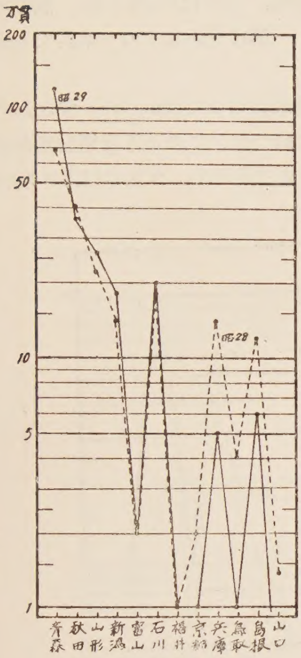
不漁の原因は，北区では佐渡～富山湾漁場の夏ブリ・冬ブリ，特に冬ブリの大不漁に基いている。すなわち富山の29年漁獲高は，戦後昭和24年の20万〆に次ぐ大不漁（30万〆）で，戦後最良の年である25年の約⅓にすぎなかつた。このため，新潟・富山両県で年間漁獲高において28年比60万〆減の67万〆となつたことが北区不漁の最大原因である。

西区においては，福井の主体をなす夏ブリの内肝心の7～8月が不漁となり，結局年間で10万〆の減となつたこと（42万〆），及び隠岐島漁場における夏ブリ・冬ブリの不漁に基く島根の16万〆減（30万〆）が，西区不漁の大きな原因となつている。が要するに第10図からも判るように，主漁場の軒並み不良の年であつた。

アブラツノザメ *Squalus suckleyi*　（第11図）

全国総数の好漁（28年比117万〆増の1,070万〆）に歩調を合わせて，日本海も好漁となつた（28年比35万〆増の220万〆）。全国総数に対する日本海総数の比は22%で，28年比1%の増である。

アブラツノザメは，日本海産サメ類の大宗をなすものであり，北区における重要漁獲対象である。28年は青



第11図　日本海アブラツノザメの府県別・年別の年間漁獲高

森を除き各地共不漁であつたが，29年は石川以北では軒並みに回復し，逆に西区では各地共ますます不漁となつている。

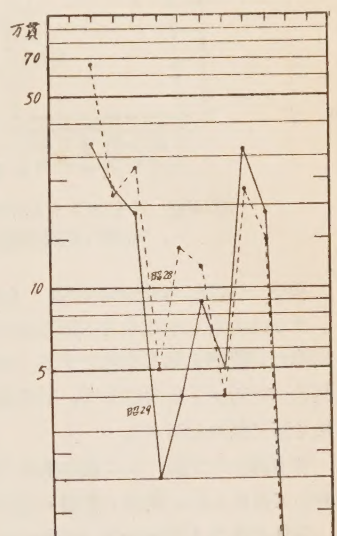
日本海でも青森県が中心で，29年の漁獲高をみても，日本海総数の53%余（118万〆）を占めている。日本海全体を通じて，青森の好漁が著しく，28年比74%（50万〆）増の118万〆の好漁であつた。青森のこの好漁は，1月及び11～12月の南下群の大群が原因であり，11月の如きは，28年の34倍（34万〆）という大漁であつた。一方漁法的原因としては，最重要漁場たる権現埼～艫作埼海区における，26年以来の延縄漁業の激増，及び，29年から初めて許可になつた底刺網漁業の激増に因る。この結果は漁獲高において，従来主漁法であつた機船底曳網漁業の漁獲高を圧倒する勢にある。ことに春の北上群のほとんどは，延縄漁業に因つている。

西区は春漁・秋漁共に不振であつた。

Ⅲ　その他の魚種（地方的に重要なもの）

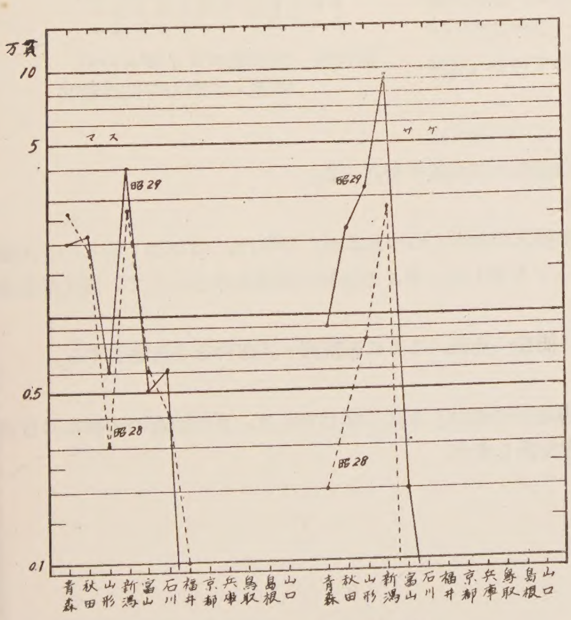
ハタハタ *Arctoscopus japonicus*　（第12図）

日本海では鳥取以北の北方魚種であり，主として底曳網で獲られる。29年日本海総数は，28年比45万〆減の146万〆であるが，この減少が全国総数における46万〆減（238万〆）の原動力となつている。日本海総数は，全国総数の61%余を占め，依然としてハタハタに関する限り，日本海の比重は大きいが，28年の全国比67%よりもかなりの低下である。



第12図　日本海ハタハタの府県別・年別の年間漁獲高

28年は兵庫及び能登以北で，最近10年来にない大豊漁の年であつたが29年は肝心の北区で漁獲が低下し，逆に京都以西で好漁となつている。



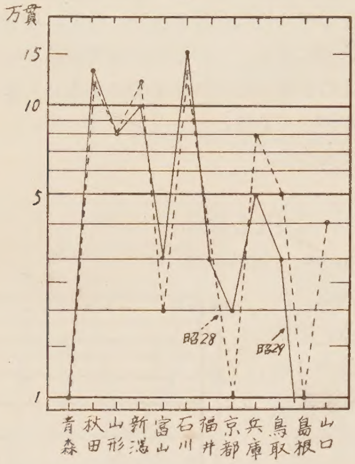
第13図　日本海マス，サケの府県別・年別の年間漁獲高

マス及びサケ　Cherry-salmon and Salmon （第13図）

日本海産は，それぞれサクラマス *Onchorhynchus masou*・サケ *Onchorhynchus keta* を主とし，共に南は若狭湾にまでも獲れるが 1,000〆

未満で，何と言つても新潟以北の魚である。量的には少い（全国比はマスは２%，サケは3.6%）が，魚価のよい点もあつて，地方的の沿岸魚種として重要である。定置網を主とするが，一部は毛釣などの一本釣でも獲られる。

サケ・マスは，ここ数年来漁獲が増大しつつあるが，29年は特にサケの好漁が目立つて良かつた。すなわち，マスは28年比１万〆増（10万〆），サケは28年の４倍（16万〆）という好漁であつた。このような増加割合のサケ>マスという傾向は，全国総数（但し日本沿岸のみ）についても言えることであつて，マスの11万〆増(478万〆）に対し，サケは158万〆の著増（446万〆）を示している。

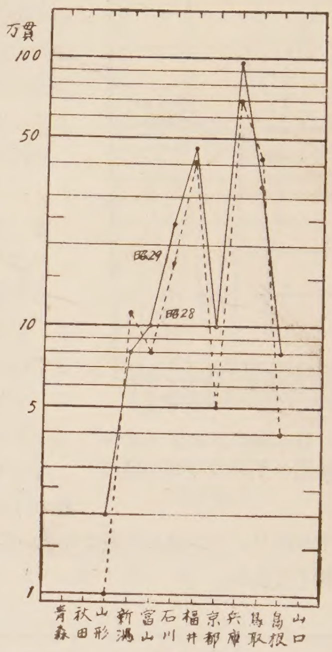


第14図　日本海タラの府県別・年別の年間漁獲高表

タラ *Gadus macrocephalus*　（第14図）

タラは大なり小なり日本海全体にわたつてとれるが，秋田〜富山湾の定置網を以て主体とする。全国総数の不漁（28年比88万〆減の 653 万〆）に対応して，日本海総数もまた減つている（28年比８万〆減の62万〆)。

日本海のタラは，ここ数年来年々減少しており，ことに西区において甚だしい。秋田・新潟・石川の３県で日本海総数の50%近くを占める。



第15図　日本海ズワイガニの府県別・年別の年間漁獲高

ズワイガニ *Chionecetes phalangium*　（第15図）

日本海のみの特産であるズワイガニは，数年来漁獲高が増大しつつあるが，29年は，27年の７倍という大豊漁であつた28年を，さらに39万〆も上まわる 239万〆を示した。多くの県特に兵庫を中心として，西区が豊漁（28年比30万〆増の194万〆）であつた。

ズワイガニは，山口を除く島根以北でとれるが，能登〜鳥取，ことに若狭湾・兵庫沖を主漁場とする。

最後に，本文に引用した資料は「昭和28年日本海漁況の経過」と全く同じであり，また図版の清書には日水研開発部町中茂技官の手を煩わしたことに対し謝意を表します。

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